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(54) Biaxial concrete masonry casting method and apparatus

(57) A mould for forming in one step a biaxial concrete masonry (C.M.) block (70 and Figure 2), comprises planar end walls (53a,54), planar top end walls (55), compression and stripper shoe (56) to firstly compress the masonry material then to strip it from the mould downwardly, pallet (60) which is detachable to allow the CM block (70) to be stripped from the mould, and plungers transversly movable in the end walls (53a) for forming apertures in the CM block, the position and number of the said plungers (64,66) being altered in accordance with the shape of the CM block required. After formation of the CM block (70) the plungers (64,66) are moved so as to allow the CM block to be displaced from the mould by the stripping shoe (56) pushing down on the CM block and removable pallet (60).

Fig. 2

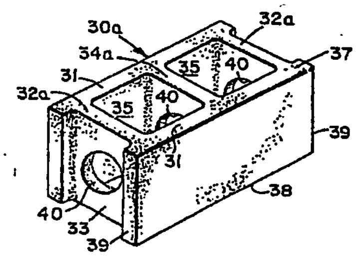

Fig. 10

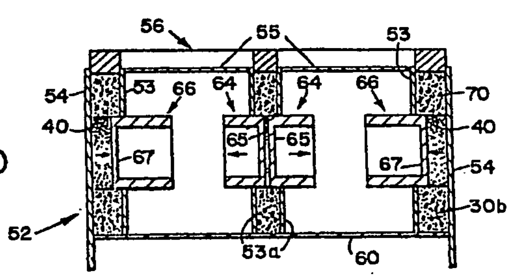

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Fig.1

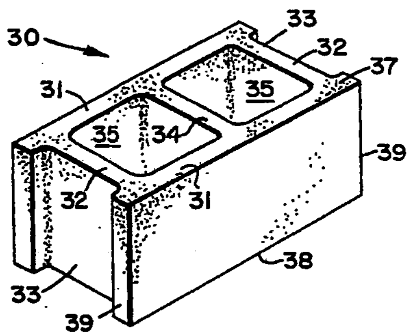

Fig.2

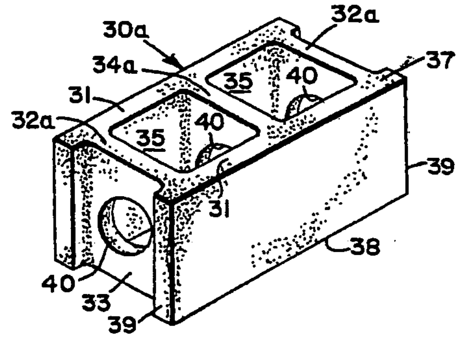

Fig.3

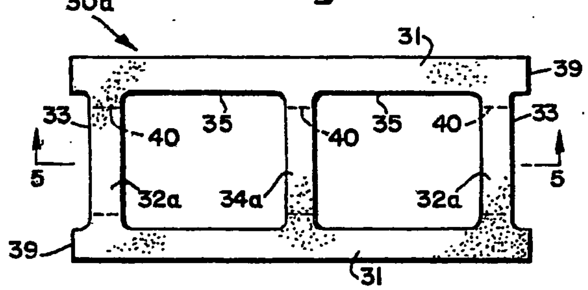

Fig.4

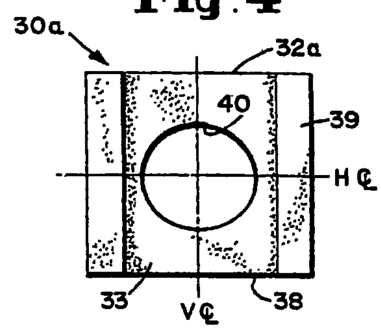

Fig.5

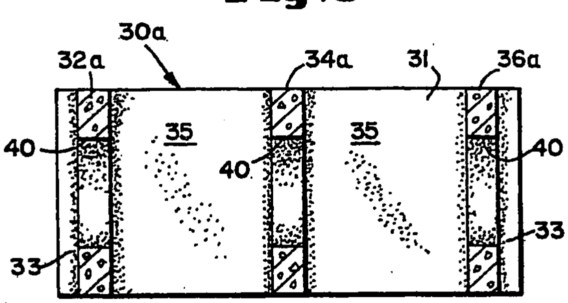

Fig.5A

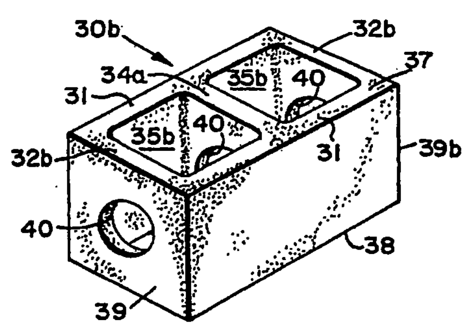

Fig. 6

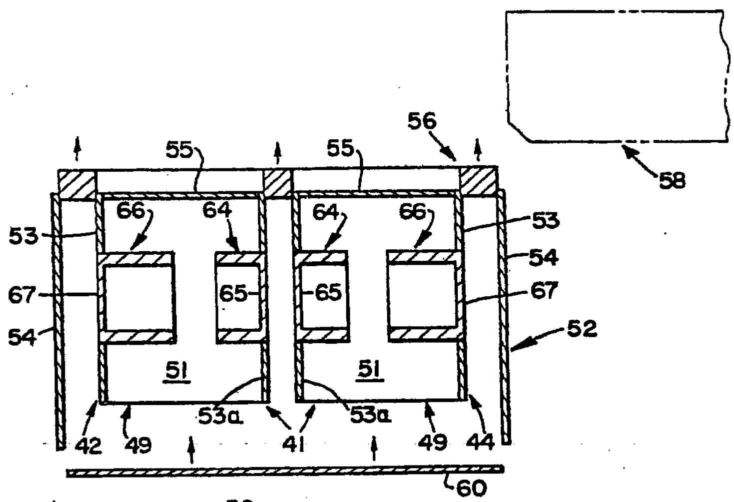

Fig. 7

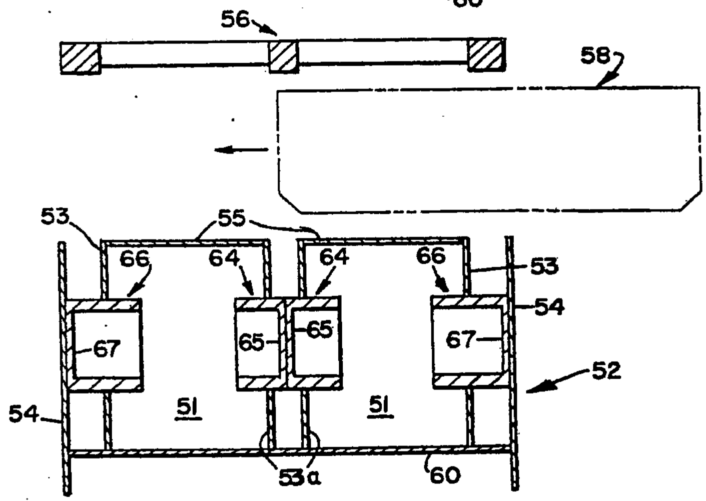

Fig. 8

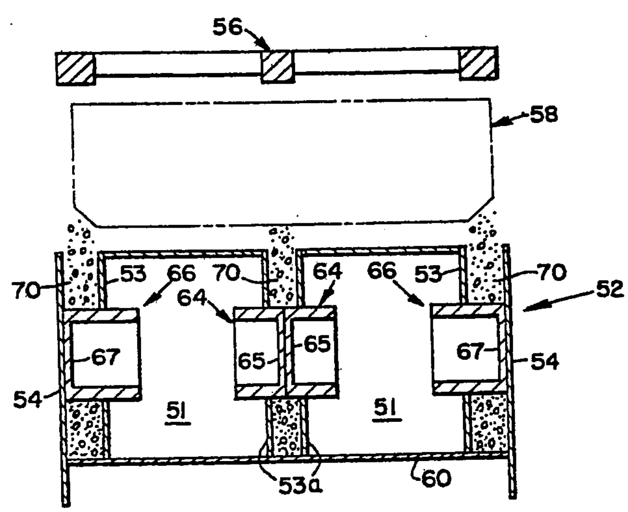

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Fig. 9

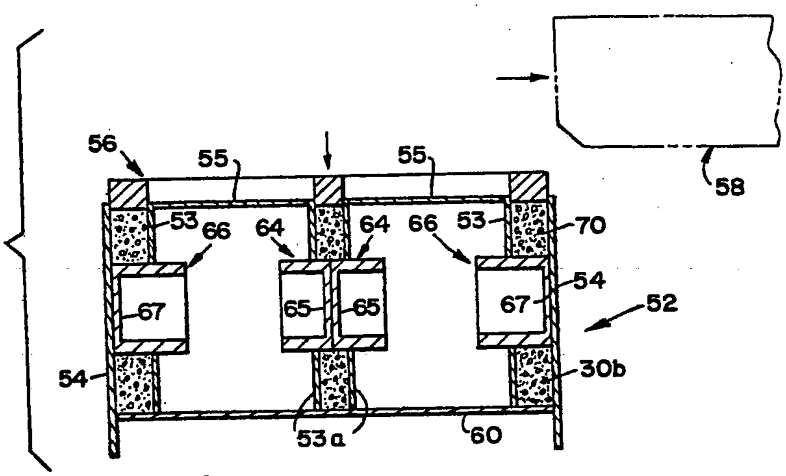
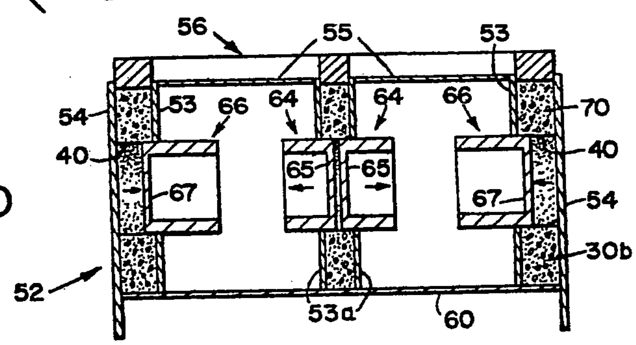


Fig.10



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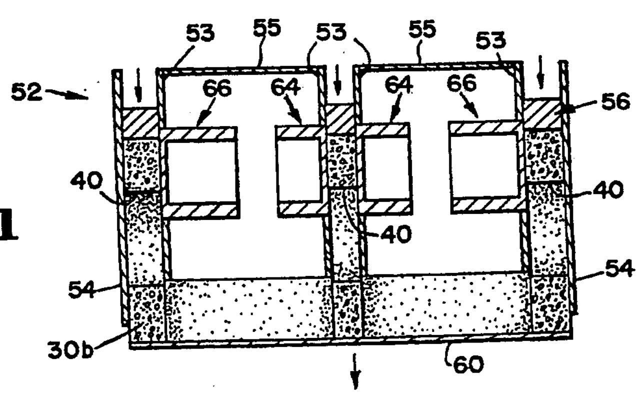

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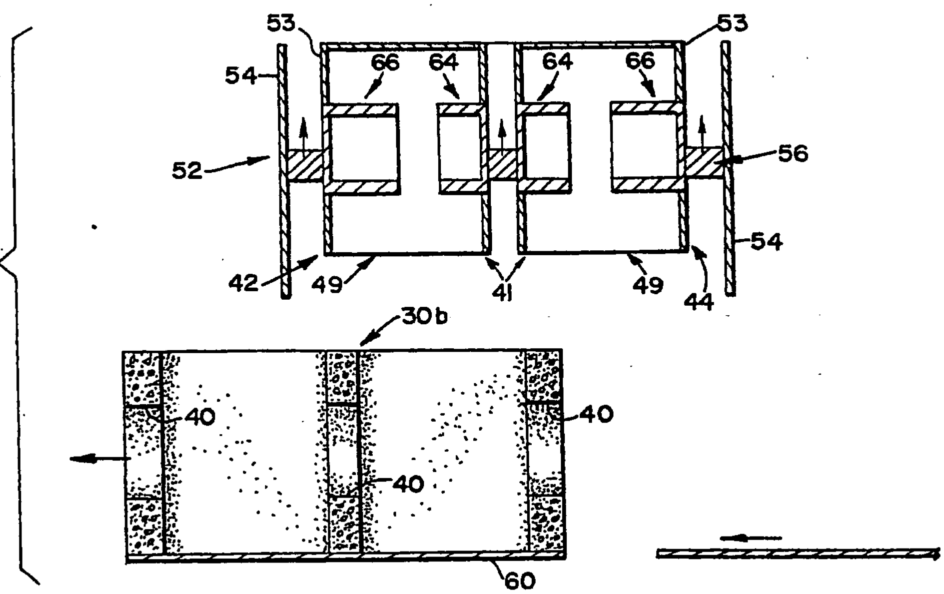
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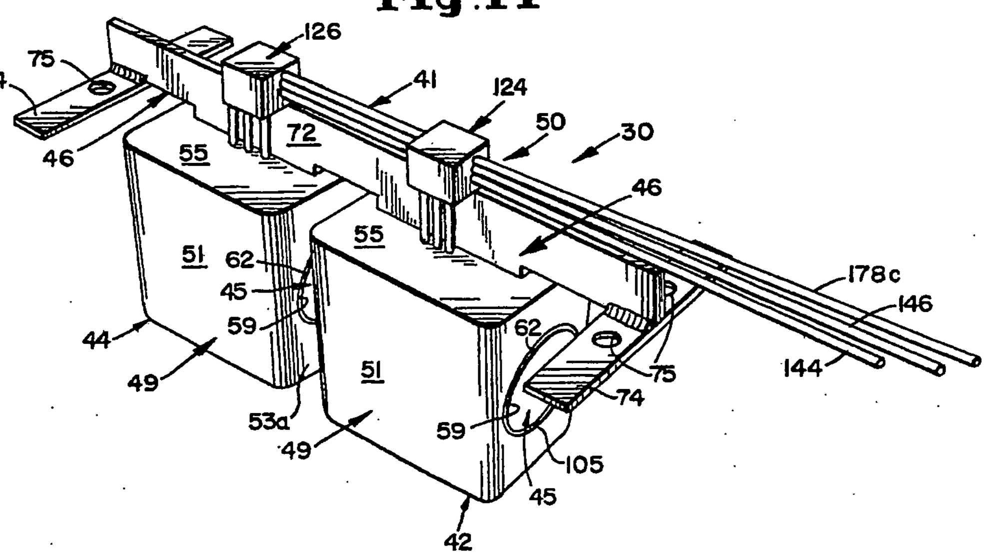
Fig.14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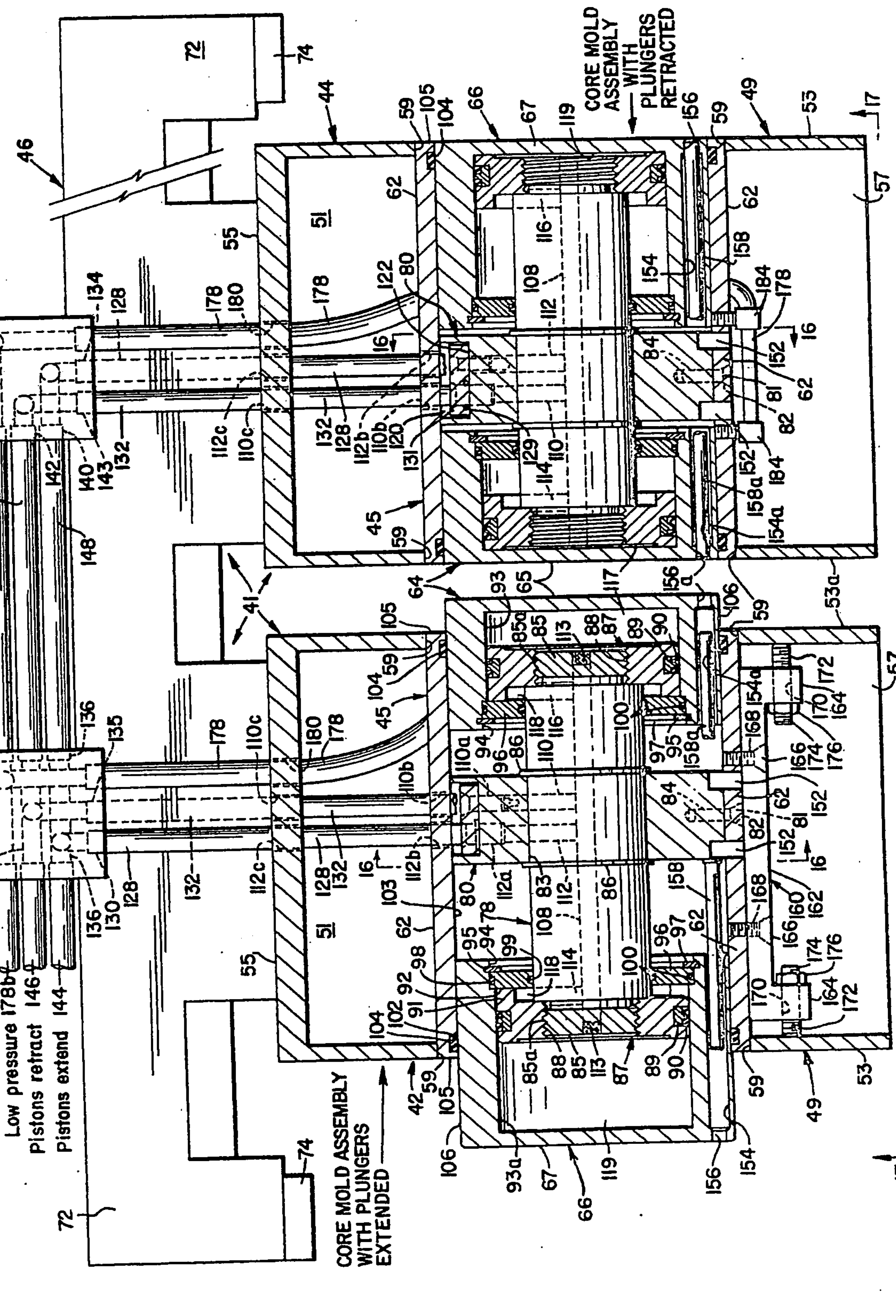

Fig 13

Fig.15

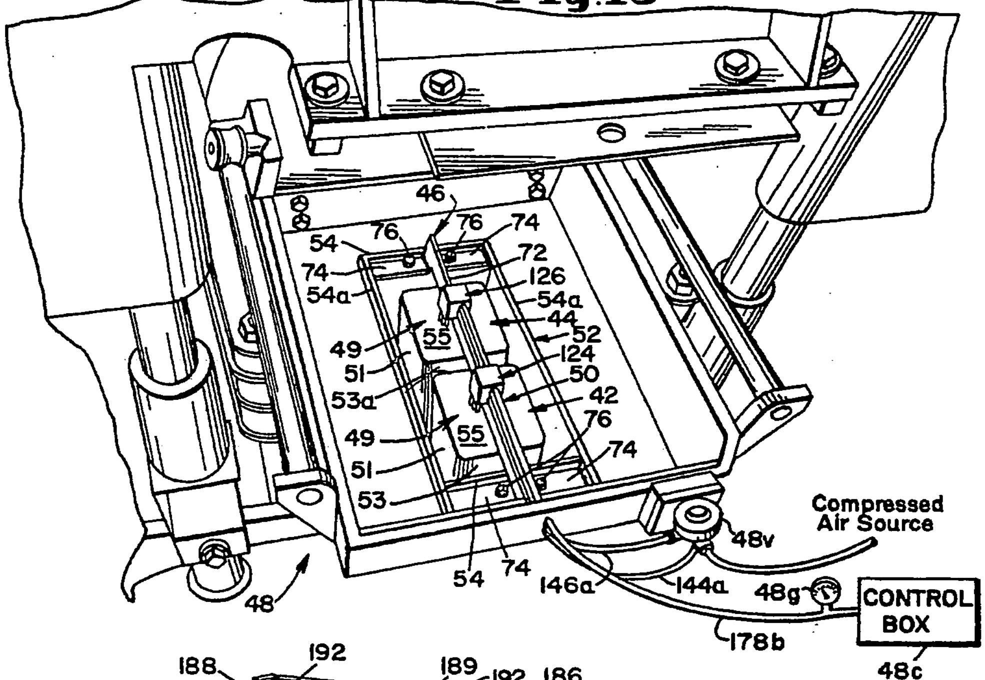

Fig.30

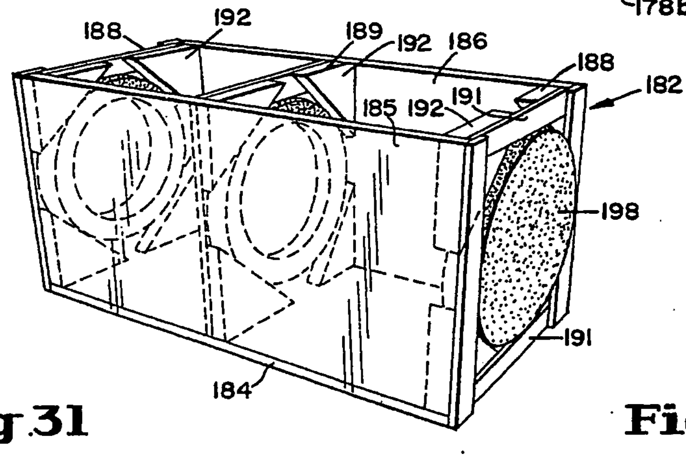

Fig.31

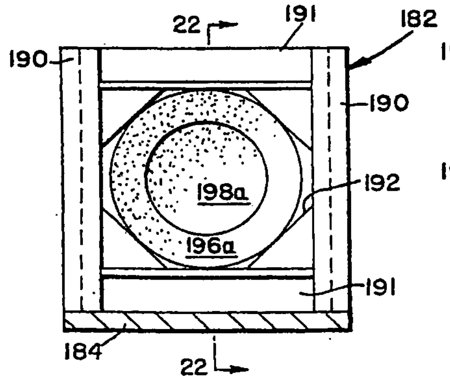

Fig.32

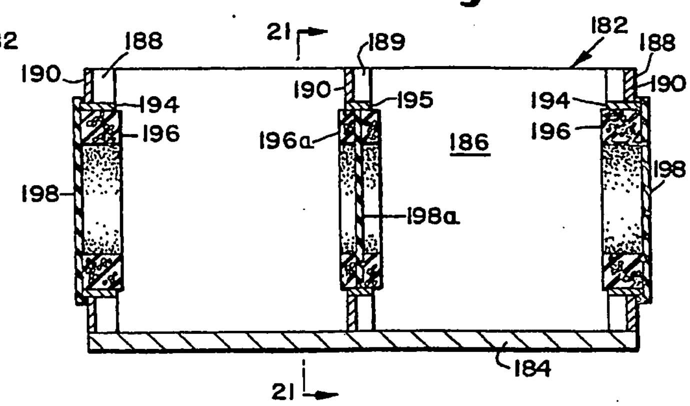

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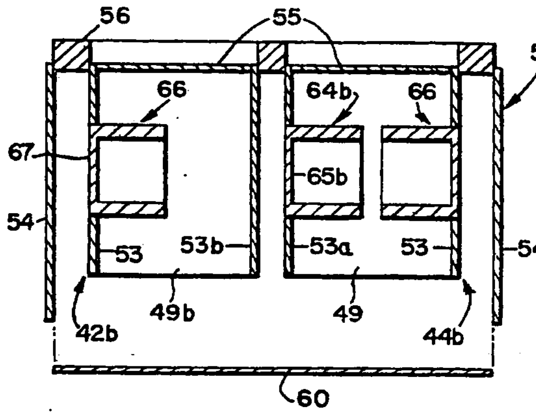
Fig.18



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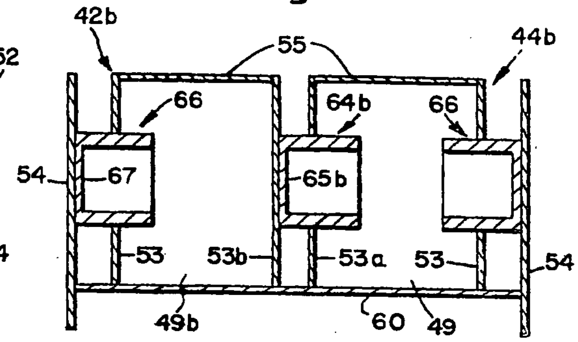


Fig.16

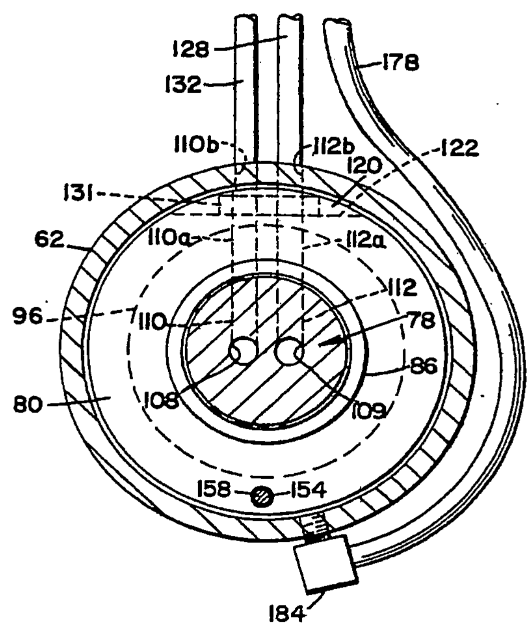


Fig.17

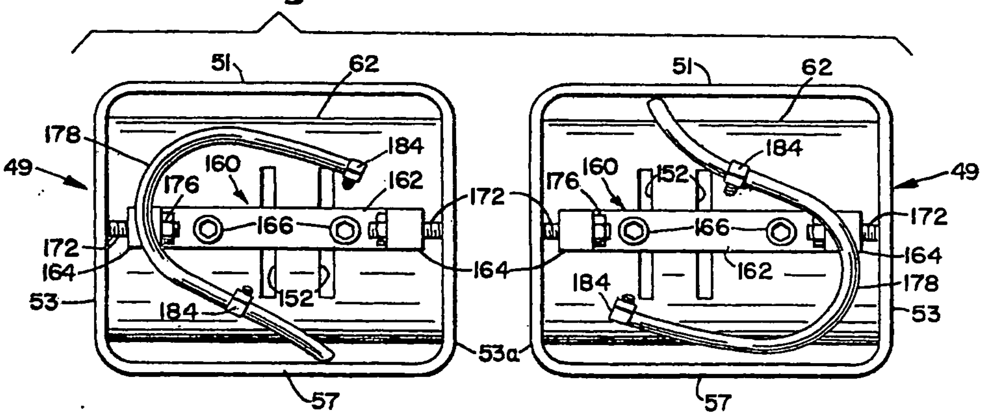
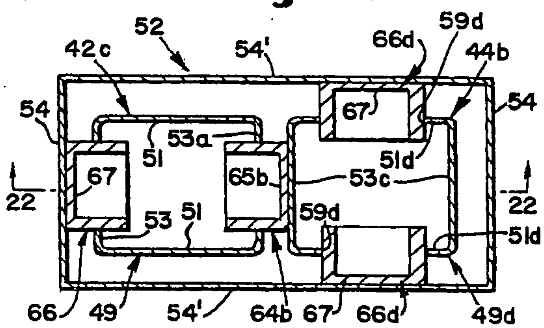


Fig.20



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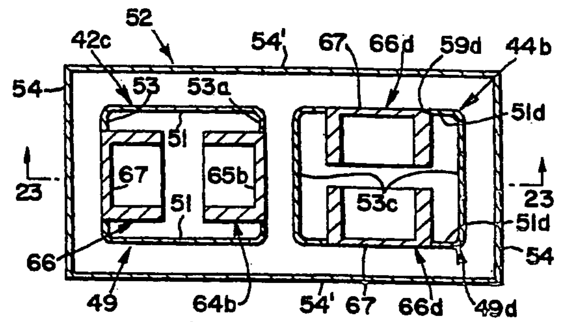

Fig.22

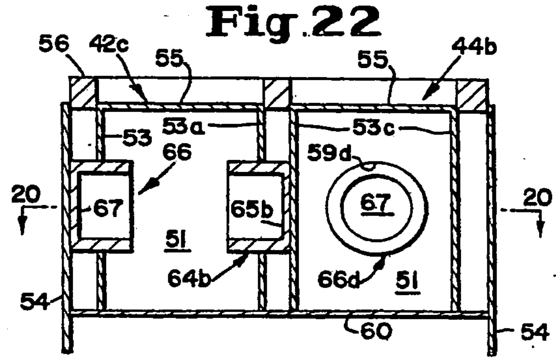

Fig.23

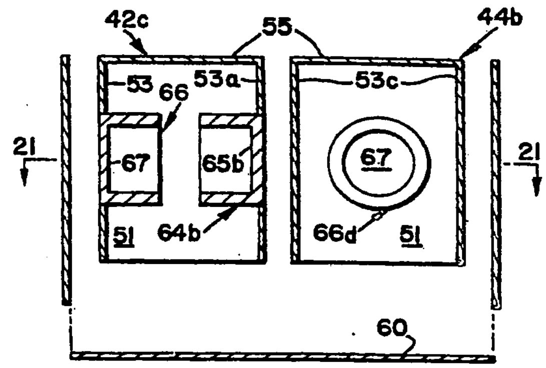

Fig.24

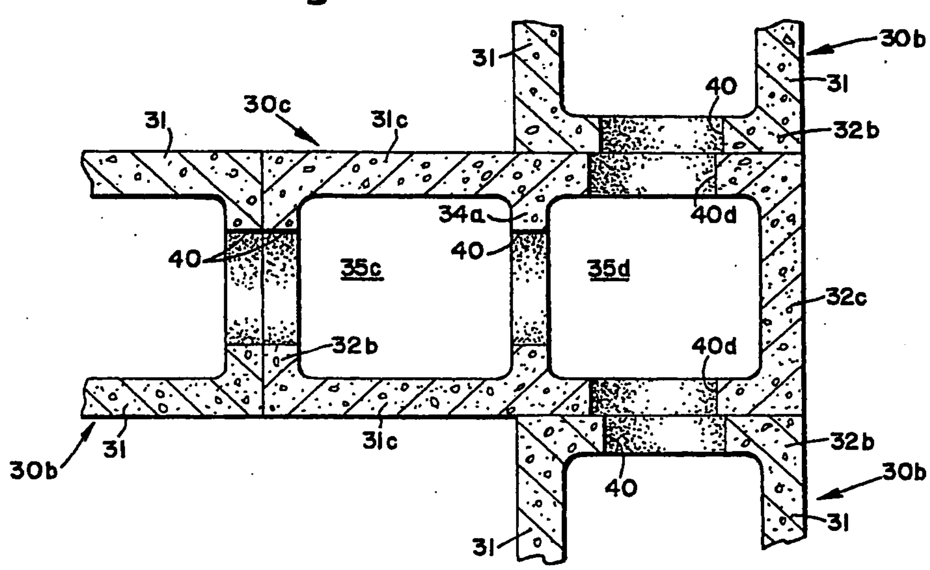

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Fig.25

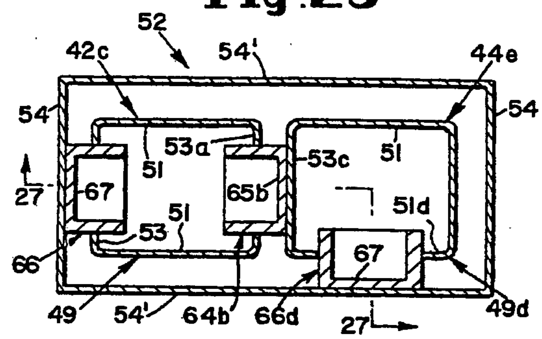


Fig.26

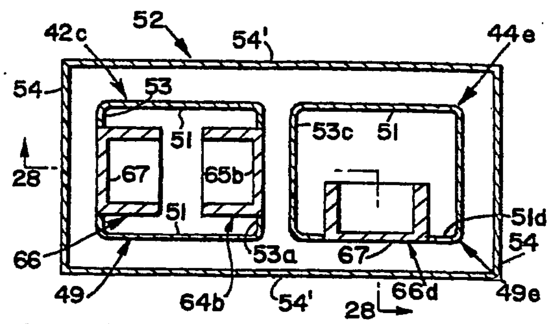


Fig.27

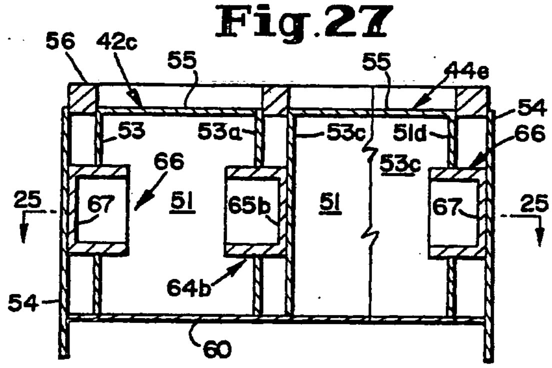


Fig.28

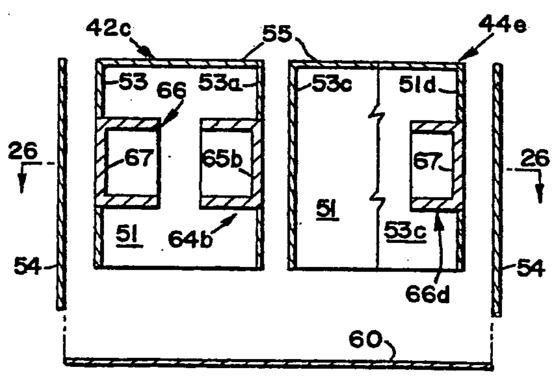
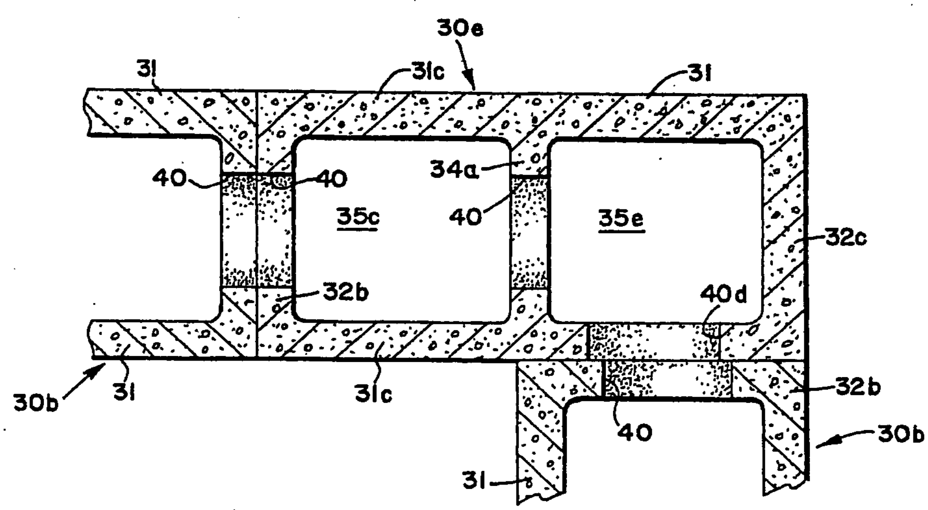


Fig.29



SPECIFICATION

Biaxial concrete masonry casting method and apparatus

The present invention relates to novel methods and apparatus for biaxial casting of concrete masonry products such as concrete masonry blocks so as to produce openings and shape indentations along the axis perpendicular to the axis of casting.

The prevailing system for manufacture of concrete masonry blocks and like units ("CM blocks", "CM units" or "CM products") is characterised by a methodology in which a fluid or semifluid concrete masonry ("CM") composition is compression cast within a mould and the CM product stripped at the opposite end from which it was fed and along the same axis. The process is similar to that of extrusion except that in the concrete masonry industry the CM product is produced in discreet segment or units rather than as a continuous casting such as is used to form products of relatively long length. One of the limiting parameters of such existing CM block manufacturing process is established by the fact that since the accretion of the moulding materials occurs lineally along the axis of the mould aperture the resultant CM product shapes which can be made may be varied only as a function of the mould aperture cross section. That is, the shape of the CM blocks of other CM products made with prior existing methods and equipment is basically limited to variation in the same axis as that of the flow of the material in the casting process. This limitation necessitates that CM product shape modification along the axis perpendicular to the flow of the material during casting becomes an expensive secondary manufacturing step which in most cases cannot be economically justified.

There have been some systems developed for making CM products provided with shape indentations along an axis perpendicular to the casting direction axis. One example is a "Horizontal Core Adapter" system made and sold by Besser Company of Alpena, Michigan, whereby it is possible to make concrete masonry blocks having top and/or bottom surfaces indented to provide interlocking blocks, reinforcement blocks or decorative blocks. However, such systems have short-comings in that the equipment is relatively expensive, the rate of CM block production is relatively slow, and the moulds tend to wear out very quickly because the CM materials are very abrasive. It is noted, however, that such prior systems here mentioned do not involve a *biaxial* concrete masonry casting method and apparatus such as disclosed herein and claimed as my invention.

It is the object of the present invention to produce a biaxial CM block in a single casting operation, without the need of any secondary operations.

According to one aspect of the present invention there is provided a biaxial casting apparatus for making a concrete masonry ('CM') blocks including four walls in substantially rectangular plan configuration enclosing a cavity extending through the block in a first direction and an opening extending through at least one of the walls in a second direction transverse to the first direction, the apparatus being adapted to be disposed in the mould of a CM casting machine with said mould including a mould box comprising four substantially vertically disposed side walls disposed in substantially rectangular plan configuration, and the apparatus comprising a mould core having four walls in substantially rectangular plan configuration and enclosing a cavity, the four walls of the mould core being intended to be spaced inwardly from the respective side walls of the mould base to provide the space for casting the four walls of the blocks, a plunger movably mounted in at least one wall of the mould core for movement between a first position extending outwardly from the said wall and a second position retracted into the cavity of the mould core, and means for moving the plunger.

According to another aspect of the present invention there is provided a biaxial casting method using a casting machine and the above apparatus, comprising the steps of disposing a pallet with respect to the mould box to provide a mould bottom, moving the plunger into its first position, feeding CM mix into the space, vertically lowering compresser/stripper means and compressing the CM mix in the space to form a CM block having an opening in at least one wall occupied by the extended plunger, retracting the plunger into its second position so as to release the plunger from the opening, and moving the compressor/stripper means and the pallet downward to strip the block from the mould box.

According to a further aspect of the present invention there is provided a biaxially cast concrete masonry ("CM") block wherever made by the above method.

The biaxial concrete masonry casting method and apparatus of this invention is achieved by a novel relatively inexpensive modification of a conventional CM mould core system to provide a biaxial CM mould core system which may be readily installed or retrofitted in commercially available CM casting machines for making CM blocks and like products. Thus conventional CM casting machines can be converted at low cost for fast and economical biaxial casting of CM blocks and other CM products so as to produce such products having openings and shape indentations along an axis of the product perpendicular to the axis of casting. It is an important feature of the present invention that the novel biaxial CM mould core apparatus for this new system is compact for use in existing moulds of commercially available CM casting machines. Specifically, such new apparatus according to the present invention incorporates reciprocal actuating plungers which cause biaxial shape modifications of the CM blocks or like CM products during casting but are contained within the confines of mould cores such as normally used for making CM products having conventional cavities extending in the direction of the axis of casting.

Although the manufacture of the biaxial CM blocks involves forming the aforementioned apertures, the rate of production is not adversely altered, remaining comparable and competitive with typical com-

mercial production rates of conventional blocks; typically one block every six seconds. Furthermore once the conduits have been formed the CM blocks can accommodate plumbing pipe and wires. Additional advantages afforded by the biaxial CM block over conventional masonry blocks include: utilising less masonry material per block, being more easily manipulated and hand-held by workmen when constructing in the field, being lighter and better for shipping and assembly. Another significant point to note is that the strength of the biaxial block is maintained adequately in the field. It is clear therefore that the biaxial CM block is an important tool in the field and when such block is provided economically by the present invention it is a significant step forward.

Embodiments of the invention will now be described, by way of example with reference to the accompanying drawings in which:-

Figure 1 is a perspective view of a conventional twin-cavity CM block such as made with commercially available CM block casting machines in which a semifluid concrete masonry mix is compression cast within a mould and stripped at the opposite end from which it was fed along the axis of casting.

Figure 2 is an isometric view of a biaxially cast CM block which is generally similar to the conventional CM block shown in Figure 1 but has apertures in the centre and two end webs of the block made during casting of the block using my novel method and apparatus for biaxial casting according to the present invention.

Figure 3 is a top plan view of the biaxially cast CM block shown in Figure 2.

Figure 4 is an end elevation view of the biaxially cast CM block shown in Figures 2 and 3.

Figure 5 is a longitudinal cross-sectional view of the biaxially cast CM block taken along line 5-5 in Figure 3.

Figure 5A is an isometric view of a modified baxially cast CM block which is like the biaxially cast CM block of Figures 2-5, but is modified so that its end webs are in alignment with the ends of its face shells rather than being spaced therefrom as in the block of Figures 2-5.

Figure 6 is a schematic or diagrammatic illustration of components of a biaxial CM casting apparatus in one phase of a biaxial CM casting process for making biaxial CM blocks according to the present invention. Figure 6 shows a biaxial CM mould core system according to the present invention installed in the mould box of a conventional CM casting machine; and this figure shows the mould being fed a conventional bottom pallet, with the compression/stripper shoe on its way up to provide access for the feed tray to the mould.

Figure 7 is a schematic of the biaxial CM casting apparatus components shown in Figure 6 but in another phase of the biaxial CM casting process wherein the bottom pallet is in place and the axial plungers are extended from the biaxial CM mould cores (whereas in Figure 6 such axial plungers are retracted within such cores).

Figure 8 is a schematic of the biaxial CM casting apparatus components shown in Figure 7 but in another phase of the process wherein semifluid concrete masonry mix is being fed into the mould cavity while said axial plungers are extended from the biaxial CM mould cores.

Figure 9 is a schematic of the apparatus of Figure 8, but shows another phase of the process wherein the feed tray has withdrawn and the stripper shoe has come down to compress the CM mix in the mould as vibration proceeds while said axial plungers are extended from the biaxial CM mould cores.

Figure 10 is similar to that of Figure 9 but shows another phase wherein the axial plungers are being retracted to inside the biaxial mould cores after completion of the CM block compression cycle.

Figure 11 is similar to Figure 10 but shows another phase wherein the axial plungers are fully retracted within the hollow mould cores and the compressed CM material formed into a CM block is being stripped from the mould cavity through simultaneously downward motion of the compression/stripper shoe and the bottom pallet.

Figure 12 is a schematic drawing showing various components of the biaxial CM casting apparatus shown in Figures 6 through 11, but Figure 12 illustrates another phase of the process wherein the compression/stripper shoe returns upward past the axial plungers which are retracted within the biaxial CM mould cores, while the newly cast CM block is being ejected on its individual pallet onto a conveyor – whereby the steps of Figures 6 through 11 can be repeated when the compression/stripper shoe moves upwardly out of and above the mould box.

Figure 13 is a partly cross-sectional view and partly side-elevational view of a biaxial CM mould core system plus mounting means and air conduit means for installing and operating the biaxial CM mould core system in a commercially available CM block casting machine. In the mould core on the right side of Figure 13, the axial plungers are shown fully retracted within the mould core as they would be in phases of operation illustrated in Figures 6, 11 and 12 thereof. In contrast, for convenient disclosure, the mould core on the left side of Figure 13 shows the axial plungers fully extended from the mould core as they would be in phases of operation shown in Figures 7, 8 and 9 thereof.

Figure 14 is a perspective view (looking from the top) of the biaxial CM mould core system plus related mounting means and air conduit means shown in Figure 13.

Figure 15 is a perspective view showing part of a conventional CM block casting machine and the biaxial CM mould core system and related components shown in Figures 13 and 14 installed in the CM block casting machine with the two mould cores of said system disposed in the mould box of the casting machine.

Figure 16 is a cross-sectional view of the biaxial plungers sub-assembly shown in Figure 13, taken along line 16-16 of the mould core shown at the right side of Figure 13.

Figure 17 is a bottom plan view of the mould core assemblies shown in Figures 13 and 14, looking upwardly along line 17-17 in Figure 13.

Figure 18 is a schematic or diagrammatic illustra-

tion of a modified biaxial CM casting apparatus for use in a CM manufacturing process for making biaxial CM blocks according to the present invention. The modified apparatus of Figure 18 corresponds to part of the embodiment shown in Figures 6-12 but shows a biaxial CM mould core system including only three axial plungers, one in the mould core at the left of Figure 18 and two in the mould core at the right of Figure 18 (said axial plungers being shown in fully retracted position in this figure).

Figure 19 is a schematic illustration of the modified biaxial CM apparatus shown in Figure 18, but with all three axial plungers shown in extended position during part of the biaxial CM casting process (similar to the corresponding parts of the apparatus shown in Figures 7, 8 and 9).

Figure 20 is a schematic illustration of another modified biaxial CM casting apparatus for use in a biaxial CM casting process to make biaxial CM "T-blocks" shown in Figure 24 according to the present inventions. Figure 20 shows a top view of the mould box and mould sides and a cross-section of the mould core assemblies taken at the level of the central axes of the axial plungers of said mould core assemblies in Figure 20.

Figure 21 is a top plan and cross-sectional view of the mould box and mould core assemblies similar to Figure 20 but showing all of axial plungers of the mould core assemblies in retracted position (instead of their being in extended position as shown in Figure 20).

Figure 22 is a vertical section of the modified embodiment for making biaxial CM T-blocks shown in Figures 20 and 21, taken along line 22-22 in Figure 20. Figure 22 shows the embodiment of Figures 20-23 with the axial plungers in extended position in a phase of operation for the embodiment of Figures 20-23 analogous to the phase of operation shown in Figure 19 for the embodiment of Figures 18-19 described below.

Figure 23 is a vertical section of the modified embodiment shown in Figures 20-22 taken along line 23-23 in Figure 21. Figure 23 shows the embodiment of Figures 20-23 in a phase of operation for said embodiment similar to the phase of operation shown in Figure 18 for the embodiment of Figures 18-19.

Figure 24 shows a modified biaxially cast CM "T-block" which is generally like the above-described biaxially cast CM block of Figure 5A but which has openings in one end web and the central web extending normal to the axis of casting, and which also has two aligned openings in the block face shells communicating with one of the twin cavities of the CM block and thus with said openings in said webs and with the other twin cavity of the T-block. Also, the T-block shown in Figure 24 can be used to provide a "T-wall-connection" as illustrated in Figure 24 when such T-block is used with two adjoining CM blocks 30b of the kind shown in Figure 5A at the ends of two intersecting walls made with such CM blocks 30b.

Figure 25 is a schematic illustration of another modified biaxial CM casting apparatus for use in a biaxial CM casting process to make biaxial CM "L-blocks" shown in Figure 29 according to the present inventions. Figure 25 shows a top view of the mould box and mould sides and a cross-section of the mould core assemblies taken at the level of the central axes of the axial plungers of said mould core assemblies in Figure 25.

Figure 26 is a top plan and cross-sectional view of the mould box and mould core assemblies similar to Figure 25 but showing all of axial plungers of the mould core assemblies in retracted position (instead of their being in extended position as shown in Figure 25).

Figure 27 is a vertical section of the modified embodiment for making biaxial CM L-blocks which is shown in Figures 25 and 26, taken along line 27-27 in Figure 25. Figure 27 shows the embodiment of Figures 25-28 with the axial plungers in extended position in a phase of operation for the embodiment of Figures 25-28 analogues to the phase of operation shown in Figure 19 for the embodiment of Figures 18-19 described below.

Figure 28 is a vertical section of the modified embodiment shown in Figures 25-27 taken along line 28-28 in Figure 26. Figure 28 shows the embodiment of Figures 25-28 in a phase of operation for said embodiment similar to the phase of operation shown in Figure 18 for the embodiment of Figures 18-19.

Figure 29 shows a modified biaxially cast CM "L-block" which is generally like the above-described biaxially cast CM block of Figure 5A but which has openings in one end web and the central web extending normal to the axis of castings, and which also has one opening in one of the block face shells communicating with one of the twin cavities of the CM block and thus with said openings in said webs and with the other twin cavity of the L-block. Also, the L-block shown in Figure 29 can be used to provide a "corner connection" as illustrated in Figure 29 when such L-block is used with one adjoining CM block 30b of the kind shown in Figure 5A at the end of a row of such CM blocks 30b.

Figure 30 is a perspective view of a "biaxial maintenance module" used for cleaning the axial plungers of the biaxial CM mould core system shown in Figures 13 and 14 at the end of a particular run or working day or the like.

Figure 31 is an end elevation view of the biaxial maintenance module shown in Figure 30.

Figure 32 is a longitudinal sectional view of the biaxial maintenance module shown in Figures 30 and 31, taken along line 32-32 in Figure 31.

In the accompanying drawings, like parts are identified with like numerals. Modified components or parts are sometimes identified by like numerals plus subscripts as below set forth to conveniently indicate similarities and differences between various embodiments.

Reference is now made particularly to Figure 1 which shows a conventional twin-cavity CM block generally indicated at 30. CM block 30 comprises two relatively elongated substantially parallel face shells 31 which are interconnected by two laterally extending end webs 32 and a centre web 34. The two face shells 31 and the three webs 32, 34 form two cavities

35 which extend through the CM block 30 from the top 37 to the bottom 38 thereof in the direction of the axis of casting of conventional CM block 30 in a conventional commercially available CM block casting machine. Each of block cavities 35 has a substantially rectangular cross-section, and both cavities 35 have substantially the same dimensions. Each of face shells 31 are of like thickness, and each of the three webs 32, 34 are of like thickness. (Representative dimensions of the conventional twin-cavity CM block 30 and its components are the same or substantially the same as dimensions of corresponding components of the below-described novel biaxially cast CM block generally indicated at 30a in Figures 2-5).

Reference is now made particularly to Figures 2-5 which show a novel biaxially cast twin-cavity CM block generally indicated at 30a. Biaxially cast CM block 30a comprises longitudinally extending substantially parallel face shells 31 which are interconnected by two laterally extending end webs 32a and a centre web 34a. The face shells 31 and the three webs 32a, 34a form two cavities 35 which extend through the block 30a from the top 37 to the bottom 38 thereof in the direction of the flow of CM material during casting of biaxially cast CM block 30a. For a suitable and typical biaxially cast twin-cavity CM block made according to the present invention, the various nominal dimensions of components of CM block 30a would be substantially as follows: overall length of face shells 31 in direction perpendicular to the axis of casting is 15.625 inches; thickness of face shells 31 is 1.25 inches; overall block width measured between the two outer surfaces of face shells 31 is 7.625 inches; transverse distance between the inside surfaces of face shells 31, and thus the transverse dimension of each cavity 35, is 5.125 inches; each of end webs 32a is inset from ends 39 of the block 0.75 inches; the thickness of each of webs 32a and 34a is 1 inch; and the distance between each end web 32a and centre web 34a, and thus the longitudinal dimension of each cavity 35, is 5.56 inches; the height of the block 30a between top 37 and bottom 38 is 7.6 inches.

The biaxially cast CM block 30a of Figures 2-5 differs from the conventional CM block 30 of Figure 1 in that there are openings or apertures 40 extending through each of the end webs 32a and the centre web 34a with the axis of each opening 40 being substantially normal to the direction of material flow during casting (i.e., the "axis of casting"). The openings 40 in the webs 32a and 34a are made by varying the mould aperture during casting and timing such variation of mould aperture in such a way as to result in variation of the shape of the CM block 30a by providing openings 40 which are formed normal to the axis of casting without a secondary manufacturing operation, as further below explained. The openings 40 in webs 32a and 34a of biaxially cast CM block 30a having typical dimensions above-described may have a diameter of about 3 to 4 inches. The centre of openings 40 is located on, or substantially on, the block's vertical centreline VCL which is midway between the outer surfaces of block face shells 31; and the centre openings 40 is also located at or slightly below the block's horizontal centreline HCL which is at the vertical midpoint of the block between top 37 and bottom 38. The configuration, size and location of biaxialaly cast openings 40 must be such as to avoid problems of inducing cracking in the manufacture of biaxially cast CM blocks 30a. The openings 40 of CM block 30a are likely to be circular as shown in Figures 2-5, and located and sized as hereinabove set forth. The configuration, size and location of biaxially cast openings such as 40 are a function of the dimensions of the biaxially cast CM block and its components and of the size, shape and location of such openings. It is possible to use different non-circular configurations for openings 40, and different sizes and locations for such openings in relation to block centrelines HCl and VCL, as will be apparent to those skilled in the art in light of the disclosure herein.

Reference is now made to Figure 5A described above showing a biaxially cast CM block 30b which is a modification of biaxially cast CM block 30a shown in Figures 2-5 and described above with reference thereto. The biaxially cast CM block 30a of Figures 2-5 is an "open end block" having a pair of inset recesses 33 at opposite ends of block 30b made by inserting end cores in the mould box (such as shown at 54 in below-described Figure 15); this is done in like manner as providing like inset recesses 33 at opposite ends of a conventionally open end block such as shown at 30 in Figure 1. However, by not using such end cores in the mould box, the biaxially cast CM block 30b will have a modified configuration as shown in Figure 5A differing from above-described CM block 30a shown in Figures 2-5. The difference between biaxially cast CM block 30b of Figure 5A as compared to biaxially cast CM block 30a is that the end webs 32b have their outer surfaces aligned with block ends 39, and the longitudinally extending dimension of cavities 35b is correspondingly longer than that of cavity 35 in CM block 30a shown in Figures 2-5 and above described. Otherwise, components of CM block 30b shown in Figure 5A identified by like numerals in Figure 5A as in Figures 2-5 are of like configuration and size as corresponding like identified components in Figures 2-5 excepting that the longitudinal dimension of each cavity 35b is 6.31 inches in block 30b of Figures 2-5 (instead of 5.56 inches as in block 30a of Figures 2-5).

Reference is now made to Figures 6-12 and 13-15. The biaxial CM mould core system generally indicated by numeral 41 includes a pair of mould core assemblies generally indicated at 42 and 44 respectively, plus core bar assembly and mounting means generally indicated at 46 for installing the system 41 in a commercially available CM block casting machine generally indicated at 48, plus air supply means generally indicated at 50 for pneumatically operating the mould core assemblies 42 and 44 of biaxial CM mould core system 41.

The CM casting machine 48 includes a four-sided mould box generally indicated at 52 which has four vertically extending sides 54 disposed substantially at right angles to each other. The CM casting machine 48 also includes a compression and strip-

per shoe ("compression/stripper shoe") generally indicated at 56, a material feed tray generally indicated at 58, and means for raising a pallet 60 to form the bottom of the mould for casting a CM block as generally known in the art and as hereinafter discussed. (It is noted that numeral 52 is sometimes used to refer to such mould as well as to the mould box itself).

Referring especially to Figures 13-15 and 17, each of mould core assemblies 42 and 44 includes a generally rectangular-shaped mould core 49 having a pair of opposite vertically disposed like planar side walls 51, plus a pair of opposite vertically disposed like planar end walls 53 and 53a, plus a horizontally disposed planar top end wall 55, and an open bottom 57. The mould cores 49 are similar to conventional mould cores used to make conventional twin-activity CM blocks such as above-described CM block 30 shown in Figure 1; but each of mould cores 49 is modified by cutting axially aligned circular apertures 59 in opposite sides 53 and 53a thereof. A cylindrical assembly sleeve 62 is disposed within each mould core 49 and has its opposite ends mounted in apertures 59 in opposed mould core side walls 53 and 53a, as further explained below. An "inner" axially reciprocating plunger indicated at 64 is mounted in one end of cylinder 62 in each mould core assembly 42 and 44 in such manner so that (i) each plunger 64 can be retracted inside of adjacent walls 53a of its mould core 49 as shown at the right of Figure 13 and diagrammatically illustrated in Figures 6, 9, 11 and 12; and so that (ii) such plungers 64 can project outside of said mould core walls 53a as shown at the left in Figure 13 and diagrammatically illustrated in Figures 6-12. Another somewhat longer "outer" axially reciprocating plunger indicated at 66 is mounted in the other end of cylinder 62 of each mould core assembly 42 and 44 so that (i) each plunger 66 can be retracted inside of adjacent wall 53 of its mould core 49 as shown at the right of Figure 13 and diagrammatically illustrated in Figures 6, 9, 11 and 12; and so that (ii) plungers 66 can project outside of said walls 53 as shown at the left in Figure 13 and diagrammatically illustrated in Figures 6-12. It is noted that the construction and mode of operation of the axial plungers 64 and 66 are the same in each of mould core assemblies 42 and 44. However, for convenience of description of the invention herein, the mould core assembly 42 is shown at the left of Figure 13 with both of its axial plungers 64 and 66 in extended position projecting outside of walls 53, 53a of the mould core 49 in position for certain phases of the biaxial CM casting process; whereas the mould core assembly 44 is shown in the right of Figure 13 with its axial plungers 64 and 66 in retracted position with both said plungers being disposed inside the walls 53, 53a of the mould core 49 for other phases of the biaxial CM casting cycle.

In the preferred embodiment, the axial plungers 64 and 66 are energised to extend them as shown in the mould core assembly 42 in Figure 13 (and in Figures 7, 8 and 9) and to retract them as shown in the mould core assembly 44 of Figure 13 (and in Figures 6 and 11) by compressed air means as explained in detail below. However, it is noted that axial plungers like 64 and 66 of equivalent mould core assemblies like 42 and 44 could be analogously energised to extend and retract such plungers in similar manner by equivalent mechanical means, electromechanical means, hydraulic means, or a combination of the foregoing, any one or more of which may also be combined with compressed air means, as will be apparent to one skilled in the art in light of the disclosure herein.

Further details of construction and mode of operation of the biaxial CM mould core system 41, mould core assemblies 42 and 44 and their compressed air operated axial plungers 64 and 66, plus related components are set forth below.

Reference is now made particularly to the schematic or diagrammatic drawings of Figures 6-12 which show components of a biaxial CM casting apparatus in various phases of a biaxial CM casting process for making biaxial CM blocks line 30b (or 30a, using end cores) by utilising the present inventions disclosed and claimed herein.

Referring to Figure 6, this is a schematic or diagrammatic illustration showing a biaxial CM mould core system 41 installed in the mould box 52 of the CM casting machine. The sides of 53 of mould core assemblies 42 and 44 are disposed adjacent to, but suitably spaced from the two shorter sides 54 of mould box 52; and the sides 51 of mould core assemblies 42 and 44 are disposed adjacent to, but suitably spaced from the two longer sides 54a of the mould box 52. (see also Figure 15.) The other sides 53a of each mould core assemblies 42 and 44 are inwardly disposed adjacent to but spaced from each other a suitable distance. As shown in Figure 6, each of the shorter and longer axial plungers 64 and 66 of mould assemblies 42 and 44 is wholly retracted within the side walls 53 and 53a of its mould core 49. Figure 6 shows a phase of operation of the biaxial CM casting apparatus and a step in the biaxial CM casting method according to this invention wherein the feed tray 58 containing the semifluid CM mix is off to the side of the mould 52, the compression/stripper shoe 56 is being moved on its way up to provide access for the feed tray 58 to the mould 52 and a conventional bottom pallet 60 is being moved upward to form the bottom of the mould 52.

Referring now particularly to Figure 7, this is a schematic or diagrammatic illustration of the biaxial CM casting apparatus components shown in Figure 6, but showing such components in a subsequent phase of operation to carry out the biaxial CM casting process according to this invention. In this phase, the bottom pallet 60 is in place to form the bottom of the mould 52, and the compression/stripper shoe 56 is above the level of the feed tray 58 which is moving into position over the mould box 52 for purposes of feeding the semifluid CM mix into mould 52. In this phase, all axial plungers 64 and 66 are caused by compressed air to project in extended position from the mould cores 49 so that the ends 67 of the longer axial plungers 66 abut against adjacent side walls 54 of the mould box 52 and the ends 65 of the shorter axial plunger 64 abut against each other as shown in Figure 7.

Reference is now made particularly to Figure 8 which is a similar schematic illustration of the apparatus components shown in Figures 6 and 7, but showing such components in another subsequent phase of operation to carry out the biaxial CM casting process according to this invention. In this phase, semifluid CM mix shown at 70 is fed into the cavity of mould 52 while said axial plungers 64 and 66 are still extended from the mould core assemblies 42 and 44 as shown in Figure 7 and explained above with reference to Figure 7.

Reference is now made particularly to Figure 9 whch is a similar schematic illustration of apparatus components shown in Figure 8 but showing still another subsequent phase of the biaxial CM casting process of this invention. In this phase, the feed tray 58 has been laterally withdrawn from its position over the mould 52 permitting the compression/stripper shoe 56 to come down and compress the CM mix 70 in the mould 52 as vibration of the mould proceeds by conventional means incorporated in CM casting machine 48. During this phase of operation said axial plungers 64 and 66 remain extended from the mould cores 42 and 44 as shown in Figures 9, and shown and described above with reference to Figures 7 and 8. Hence, in the phases of operation shown in Figures 9 and 8 the extended axial plungers 66 have their ends 67 abutting adjacent mould box side walls 54 and axially extending plungers 64 have their ends 65 abutting each other so as to prevent CM mix 70 from filling in the spaces in mould 52 thus occupied by the portions of said extended plungers 64 and 66 projecting from both mould cores 49, as will be apparent from Figures 9 and 8 and the foregoing description thereof. This causes the formation of openings 40 in end webs 32b and in centre web 34a of the biaxially cast CM block 32b shown in Figure 5A and described above with reference to that figure plus Figures 2-5. (This is in contrast to conventionally cast twin-cavity CM blocks 30 such as shown in Figure 1, which have solid end and centre webs due to use of conventional mould cores that do not incorporate axial plungers 64 and 66, or other equivalent means.)

Reference is now made particularly to Figure 10 which is a schematic illustration of apparatus components similar to that of Figure 9, but shows a next phase of apparatus operation for carrying out the biaxial CM casting process according to this invention. In this phase, the axial plungers 64 and 66 are in the process of being retracted by compressed air to dispose said plungers 64 and 66 inside the walls of the mould cores 49 after completion of the block compression phase of the process described above with references to Figure 9 (and Figure 8).

Reference is now made particularly to Figure 11 which is a schematic illustration similar to Figure 10 but shows another subsequent phase of apparatus operation to carry out the biaxial CM block casting process of this invention. In this phase, the axial plungers 64 and 66 are fully retracted to within the side walls of the mould cores 49, whereby the compressed CM material formed into CM block 30b having three web openings 40 can be and is stripped from the cavity of mould 52 by simultaneous downward motion of the compression/stripper shoe 56 and bottom pallet 60.

Reference is now made particularly to Figure 12 which is a schematic illustration of various apparatus components shown in Figure 11, but shows still another subsequent phase of apparatus operation to carry out the biaxial CM casting process according to this invention. In this phase, the compression/stripper shoe 56 returns upward past the mould core assemblies 42 and 44 and their axial plungers 64 and 66 which are retracted within the side walls of the mould cores 49, while the newly made biaxially cast CM block 30b is being ejected on its individual pallet 60 onto a conveyor.

After the compression/stripper shoe 56 moves upwardly out of and above the mould 52 the above-discussed steps of Figures 6 through 12 then may be and are repeated to carry out the next cycle for moulding the next CM block 30b in like manner as described above with reference to Figures 6 through 12 in light of Figures 13-17 and description thereof further amplified below.

Reference is now made particularly to Figure 13, together with Figures 14-17, for further detailed description of the biaxial CM mould core system generally indicated at 41, the like mould core assemblies generally indicated at 42 and 44, and the core bar and mounting assembly generally indicated at 46. The core bar assembly and mounting system includes a conventional-type commercially available core bar assembly comprising an elongated core bar 72 which as a configuration as shown in Figures 13-15 and is welded to the top end wall 45 of each of mould cores 49 (core bar 72 is usually made from high strength steel about one-half inch thick). Core bar 72 has a pair of mounting brackets 74 welded to its ends and extending perpendicular to the longitudinal axis of core bar 72. Each of mounting brackets 74 is provided with a pair of holes 75 for receiving four machine screws 76 to lock the CM mould core system 41 in place within mould box 52 to provide a biaxial CM casting mould for carrying out the biaxial CM casting process according to the present inventions.

Reference is now made particularly to Figure 13 (and also Figures 14 and 17). As previously noted, mould cores 49 are like conventional commonly available mould cores for commercially available CM casting machines excepting that mould cores 49 are modified by cutting axially aligned circular apertures 59 in opposite sides 53 and 53a of each mould core 49. It is noted that, like in conventional mould cores, the sides 51, 53 and 53a of mould core 49 are disposed at a slight angle toward the central longitudinal axis of mould core 49 whereby the bottom edge of each of said mould core walls at the bottom opening 57 of mould core 49 is disposed a slight distance closer to said central longitudinal mould axis than the top portion of said side walls of mould core 49 which join with the top end walls 55 thereof. For example (as in a typical conventional mould core), the bottom edges of said side walls of each mould core 49 will be each disposed closer to the mould core's longitudinal central axis than the top edges of said side walls by about one-eighth

inch. The sides of each mould core 49 (like in conventional mould cores) are disposed at such a slight angle to the mould core's central axis to facilitate stripping of the compressed CM block such as shown at 30b in Figures 5A (or block 30a of Figures 2-5) after compression of the CM block so as to more readily remove the newly formed CM block from the mould and the casting machine.

Reference is now made especially to Figure 13 (and Figures 16-17) for detailed description of mould core assemblies generally indicated by numerals 42 and 44. As previously noted, for convenience in disclosure of the invention herein, mould core assemblies 42 and 44 are the same in construction and mode of operation, but mould core assembly 42 is shown at the left of Figure 13 with plungers 64 and 66 thereof extended, whereas mould core assembly 44 is shown at the right of Figure 13 with plungers 64 and 68 retracted. It also is noted that, for convenience in disclosure of the invention therein, certain features of said like mould core assemblies 42 and 44 are shown in the mould core assembly 42 at the left of Figure 13 but are not shown in the mould core assembly 44 at the right of Figure 13, and vice versa. (Features within the scope of the preceding sentence are noted in description of mould core assemblies 42 and 44 with reference to Figure 13.) It is further noted that, for convenience of disclosure of the invention herein, some features of each of like mould core assemblies 42 and 44 are shown in the section drawings of Figure 13 in the same plane, whereas in actual construction some features are not in the same plane but are angularly or otherwise displaced with respect to the longitudinal axis of cylindrical assembly sleeve 62. (Features within the scope of the preceding sentence are noted in description of mould core assemblies 42 and 44 with reference to Figure 13.)

Still referring especially to Figure 13, there is centrally disposed within cylindrical asembly sleeve 62 an elongated cylindrical manifold member generally indicated at 78 which extends through the central aperture of an annular-shaped ring generally indicated at 80. Ring 80 supports manifold member 78 and ring 80 are in turn supported within the cylindrical assembly sleeve 62 (sometimes called "assembly cylinder 62" or "plungers assembly cylinder 62"). When assembled, cylinder 62, cylindrical manifold member 78 and annular-shaped manifold supporting ring 80 have substantially coincident longitudinal central axes.

Referring especially to like mould core assemblies 42 and 44 in Figure 13, the annular manifold support ring 80 is secured to the assembly cylinder 62 in the interior thereof by a plurality of machine screws like 81 extending through apertures like 82 in the wall of assembly cylinder 62 and respectively threaded into a plurality of drilled and threaded holes like 84 which extend radially into annular ring 80 from its outer periphery. In a typical embodiment, annular ring 80 is secured to assembly cylinder 62 by three similar machine screws like 81 which are threaded into three similar holes like 84 as shown in Figure 13, and are located in the same plane normal to the longitudinal axis of assembly cylinder 62 and annular ring 80; and each of the other two screws like 81 are spaced at an angle of 90 degrees from screw 81 shown in Figure 13 (such other two screws are not shown in the drawing).

Still referring to Figure 13 (and especially to the mould core assembly 42 at the left of that figure for convenient description), manifold member 78 which extends through and is supported in the central aperture 83 of annular ring 80 also is laterally secured to ring 80 by a pair of like retaining rings 86 held in circular recessed groves extending into the outer periphery of manifold member 78 on opposite sides of manifold support ring 80. The manifold member 78 is provided at each of its opposite ends with a reduced diameter hub 85 which is externally threaded at 85a. An annular stationary piston member generally indicated at 87 is secured to each of the opposite ends of manifold member 78 by means of threads in the central aperture 88 of piston members 87 mating with threads 85a on each of hubs 85 at the opposite ends of manifold member 78. Each stationary piston member 87 is provided on its outer cylindrical periphery with an annular recessed groove 89 in which there is mounted any suitable commercially available annular sealing ring (or rings) shown at 90. Each stationary piston member 87 also is provided on its outer cylindrical periphery with an annular flanged section 91 which has an annular planar end 92 disposed perpendicular to the longitudinal axis of cylindrical stationary piston 87. The axis of stationary piston 87 is coincident with the above described axes of assembly cylinder 62, ring 80, and manifold member 78.

Still referring to Figure 13 (and especially to the mould core assembly 42 at the left thereof for convenient description), it is noted that cylindrical axial plungers 64 and 66 in each of mould core assemblies 42 and 44 are of like configuration excepting that axial plungers 66 are longer than axial plungers 64 in the direction of their longitudinal axis. Also axial plungers 64 and 66 are mounted on their respective coacting stationary pistons 87 in the same way and operate in relation thereto in like manner as herein described. Each axial plunger 64 is provided with an internal hollow cylindrical portion 93, and each axial plunger 66 is provided with an internal hollow cylindrical portion 93a which is like said portion 93 of axial plunger 64 excepting that 93a is longer than 93. The open end of each cylindrical portions 93 and 93a of axial plungers 64 and 66 is provided with an internal cylindrical step section 94 which in turn is provided with an internally recessed annular groove 95 near the open ends of hollow cylindrical portions 93 and 93a of axial plungers 64 and 66 respectively. An annular ring 96 is mounted in internally steped section 94 of each axial plungers 64 and 66; and each said annular ring 96 is secured with one flat side thereof abutting annular face surface 92 on the end of cylinder flange portion 91 of each stationary piston 87, by means of retaining rings 97 disposed in said annular grooves 95. Each of said annular rings 96 is provided with a groove 98 on its exterior cylindrical surface and with a groove 99 on its interior cylindrical surface 97; and suitable commercially available sealing rings 100 are

mounted in each of said grooves 98 and 99.

Still referring to Figure 13 (and especially to mould core assembly 42 at the left thereof for convenient description), annular grooves 102 are provided adjacent opposite ends of each assembly cylinder 62 in the interior cylindrical surface 103 of cylinder 62. Sweeper gaskets 104 are provided in each of said grooves 102 and each gasket engages the exterior cylindrical surface of associated axial plungers 64 and 66. Referring now also to Figures 9-11, sweeper gaskets 104 are made of any suitable commercially available material and size so that when plungers 64 and 66 have been extended and exposed to CM mix 70 as shown in Figure 9, and said plungers are then retracted to inside the mould cores 49 as shown in Figures 10 and 11, the sweeper gaskets 104 will wipe particles of CM mix off the cylindrical exteriors of plungers 64 and 66.

At least the exterior of axial plungers 64 and 66 including their respective ends 65 and 67 are coated with a sufficient thickness of a commercially available hard and abrasion-resistant chromium-steel alloy or like suitable material. (As a practical matter, such alloy coating is generally applied electrochemically whereby all surfaces of axial plungers 64 and 66 will be thus coated with such metal alloy.) At least the interior surface 103 of each assembly cylinder 62 and the outer edge surface 105 thereof are similarly coated with an adequate thickness of a commercially available hard and abrasion-resistant metal such as chromium-steel alloy or like suitable material. (Again, for practical production reasons all surfaces of the assembly cylinder 62 may be coated with such metal alloy.) The commercially available alloy (or alloys) used for coating the interior surface 103 of assembly cylinder 62 and the exterior surfaces 106 of axial plungers 64 and 66 is not only selected for quality of hardness and resistance to abrasion but is also selected for anti-galling properties so as to provide a self-lubricating effect between said surfaces of assembly cylinders 62 and axial plungers 64 and 66. By specially coating cylindrical assembly sleeve 62 and plungers 64 and 66, as above-discussed, the axial plungers sub-assembly generally indicated at 45 (comprising assembly sleeve 62, annular ring 80, elongated manifold member 78, stationary piston 87, axial plungers 64 and 66, and related components described with specific reference to Figure 13) will generally have a useful life of three to five times the useful life of core members 49 in typical commercial operations using biaxial CM casting apparatus and method inventions disclosed herein. Therefore, the axial plunger sub-assembly 45 may be made and sold by commercial sources differing from the commercial sources providing the core bar assembly 46 which will usually also supply the mould cores 49.

Referring now particularly to Figures 13 and 16, each of like manifold members 78 of mould core assemblies 42 and 44 is provided with a pair of drilled holes 108 and 109 extending longitudinally through manifold member 78 from end to end, spaced from and substantially parallel to the axis of member 78. Each manifold member 78 is also provided with a pair of drilled holes 110 and 112 extending inwardly from the outer periphery of manifold member 78 so that hole 110 intersects said longitudinally extending hole 108 in manifold member 78, and hole 112 intersescts longitudinally extending hole 109 in manifold member 78. Also each manifold member 78 is provided near each opposite end thereof with a pair of drilled holes 114 and 116 extending inward from the outer periphery of manifold member 78 and intersecting said longitudinal extending hole 108 in each manifold member 78. Also the opposite ends of hole 108 in each manifold member 78 (but not hole 109 thereof) are sealed by plugs shown at 113 in mould core assembly 42 at the left of Figure 13. Referring especially now to mould core assembly 42 at th left of Figure 13, said holes 114 and 116 are located adjacent each of stationary pistons 87 at the opposite ends of manifold member 78 so that compressed air will pass from end-sealed manifold hole 108 through holes 114 and 116 to the sealed-off space 118 between the stationary piston 87 and the sealed annular ring 96 secured to each of axial plungers 64 and 66. As a result, compressed air injected into the sealed-off spaces 118 via manifold hole 108 and said holes 114 and 116 will apply positive force to axial plungers 64 and 66 causing them to move from the extended position shown in mould core assembly 42 at the left of Figure 13 to the fully retracted position of plungers 64 and 66 shown in the mould core assembly 44 at the right of Figure 13. To cause plungers 64 and 66 to extend, compressed air injected via manifold member hole 109 through the open ends thereof into spaces 117 and 119 of plungers 64 and 66 will apply positive force to the axial plungers 64 and 66 will apply positive force to the axial plungers 64 and 66 causing them to move from retracted position shown in mould core assembly 44 at the right in Figure 13 to the fully extended position of plungers 64 and 66 shown in the mould core assembly 42 illustrated at the left of Figure 13.

Still referring particularly to Figure 13 and 16, a top portion of ring 80 is milled to provide a recessed cavity 120 having a bottom surface 122 which be disposed substantially horizontally when the plungers sub-assembly 45 is assembled in mould core 49. A pair of holes 110a and 112a are drilled in ring 80 inwardly from surface 122 of recess 120 in ring 80 so that when each ring 80 is assembled on its associated manifold member 78, said hole 110a in ring 80 is a continuation of hole 110 in member 78 and said hole 112a in ring 80 is a continuation of hole 112 in member 78. Each cylindrical assembly sleeve 62 is provided with drilled holes 110b and 112b which are respectively substantially axially aligned with said holes 110+110a and 112+112a. The top wall 55 of each mould core 49 is provided with drilled holes 110c and 112c which are disposed substantially vertically above holes 110b and 110c in cylindrical assembly sleeve 62. It is noted that holes 110c and 112c are located on opposite sides of care bar 72.

Referring now to Figure 13 and Figures 14-15, an air coupling block 124 is welded or otherwise secured to care bar 72 above holes 110c and 112c in mould core 49 of mould core assembly 42; and an air

coupling block 126 is simularly secured to core bar 72 above holes 110c and 112c in mould core 49 of mould core assembly 42. Metal tubes 128 of suitable material and size for conducting compressed air are disposed on opposite sides of core bar 72 and tubes 28 are connected at one end by press-fit or in other suitable manner to air passage holes 130 and 134 drilled in air coupling blocks 124 and 126 respectively. Each of air tubes 128 extends through hole 112c in top plate 55 of one of mould cores 49 and through hole 110b in one of cylindrical assembly sleeves 62 and has its other end press-fitted in the upper enlarged portion of 112a in one of annular rings 80. The lower ends of air tubes 128 are also sealed by O-ring 129 and retainer means 131 disposed in recessed cavity 120 in ring 80 inside assembly cylinder sleeve 62. Thus compressed air fed via each coupling block 124 and 126, respectively, through its associated air tube 128 will pass through hole 110 in manifold member 78 and then via longitudinally extending hole 108 through the open ends thereof to operate axial plungers 64 and 66 so that they will extend as elsewhere herein explained. Similar metal tubes 132 for conducting compressed air are disposed on opposite sides of core bar 72, and tubes 132 are suitably connected at one end to air passage holes 135 and 143 driled in each of air coupling blocks 124 and 126 respectively. Each metal tube 132 extends through a hole 110c in top plate 55 of each mould core 49 and hole 110b in associated cylindrical assembly sleeve 62; and each tube 132 has its other lower end press-fitted in the upper enlarged portion of step hole 110a in annular ring 80. The lower ends of each of air tubes 132 are also sealed by an O-ring (like O-ring 129) and said retainer means 131 disposed in recessed cavity 120 in ring 80 inside assembly cylinder sleeve 62. Thus compressed air fed via air coupling blocks 124 and 126 respectively through tubes 132 will pass through hole 110 into longitudinally extending end-plugged hole 108 of each manifold member 78 to operate axial plungers 64 and 66 so that they will retract as elsewhere herein explained. Retainer means 131 for O-rings 129 is a plate secured in recess 120 in ring 80 by a plurality of screws (not shown) which are threaded into holes extending inwardly into ring 80 from the bottom of 122 of recess 120 (holes not shown).

Air coupling block 124 is provided with another drilled hole 136 perpendicular to and intersecting hole 130 therein and also extending through to the other side of block 124. Air coupling block 124 is provided with still another hole 138 drilled therein perpendicular to and intersecting hole 135 in block 124 and also extending to the other side of the block 124. The other air coupling block 126 is provided with a hole 140 drilled therein perpendicular to and intersecting hole 134 to form an air conduit therewith. Air coupling block 126 is also provided with another hole 142 drilled therein extending normal to and intersecting the hole 143 drilled in block 126 to provide an air conduit therethrough. An air tube 148 is similarly suitably connected at opposite ends thereof to the air hole 136 drilled in air coupling block 124 and to the air hole 140 drilled in air coupling block 126. Also, an air tube 150 is suitably connected at one of its ends to the other end of hole 138 in air coupling block 124, and the opposite end of air tube 150 is suitably connected to air hole 142 in air coupling block 126. Air tubing 144 is connected to a source of constant pressure compressed air thorugh a suitable commercially available three-way valve or like suitable means 48v, and is press-fit or otherwise suitably connected at one end in hole 136 in air coupling block 124. Air tube 146 is similarly connected to a constant pressure compressed air source and suitable commercially available three-way valve or like suitable means 48v, and is press-fit or otherwise suitably connected in the slightly enlarged end of hole 138 in air coupling block 124.

When the compressed air control means such as a three-way valve 48v is operated to provide compressed air to conduit 144 from a conventional compressed air source by suitable conventional means like a three-way valve, the compressed air will be supplied at the same time to both axial plunger subassemblies 45 of mould core assemblies 42 and 44 since they are connected in parallel to the compressed air source via conduit 144 whereby the plungers 64 and 66 of mould core assemblies 42 and 44 will simultaneously be extended outwardly to the position shown in mould core assembly 42 at the left of Figure 13 and in Figures 7, 8 and 9. More specifically, compressed air from conduit 144 passes to conduit 128 of mould core assembly 42 and simultaneously to conduit 128 of mould core assembly 44 via tubing 148 interconnecting air couplings 124 and 126. The compressed air passes simultaneously via tubes 128 to and through holes 112a to ring 80 and 122 in manifold 78 and then through longitudinally extending hole 109 in manifold 78 and out through the open ends of hole 109 into the inside portions 117 and 119 of axial plungers 64 and 66, respectively, causing said plungers to extend under the positive force exerted thereon by compressed air in the manner described. When the compressed air control means such as a three-way valve 48v is alternatively operated to provide compressed air to conduit 146, compressed air will be provided at the same time to each of mould core assemblies 42 and 44 simultaneously. In this case, the compressed air from conduit 146 passes via air coupling block 124 to and through tube 132 to mould core assembly 42, while compressed air simultaneously passes from conduit 146 via air coupling 126 through tubing 150 and air coupling 126 and through air tubing 132 to mould core assembly 44, whereby plungers 64 and 66 will simultaneously be retracted to the position shown in mould core assembly at the right in Figure 13 and in Figures 6, 11 and 12. More specifically, the compressed air simultaneously provided through tubing 132 to each of mould core assemblies 42 and 44 passes through holes 110a in ring 80 and hole 110 in manifold member 78 and then into and through the end-plugged longitudinally extending hole 108 in manifold member 78, and thence through laterally extending passages 114 and 116 into the spaces 118 behind stationary pistons 87 so as to apply a force which positively and simultaneously retracts all of plungers 64 and 66 in both of the mould core assemblies 42 and 44.

Referring particularly to Figures 13 and 17, the bottom portion of each assembly sleeve 62 and annular ring 80 in each of mould core assemblies 42 and 44 is provided with a pair of communicating slots shown at 152 so as to provide and air passage from the inside to the outside of assembly sleeve 62 in communication with the inner portions of axial plungers 64 and 66 disposed on opposite sides of ring 80 in each of mould core assemblies 42 and 44. Such slots 152 provide passages for venting of air from inside sleeve 62 and relief of pressure when the axial plungers are operated as herein explained to cause axial plungers 64 and 66 to move from the extended position shown in mould core assembly 42 at the left of Figure 13 to the retracted position shown in mould core assembly 44 at the right of Figure 13.

Referring particularly to Figure 13, a hole 154 is drilled in the cylindrical wall of each of the longer axial plungers 66 with said hole 154 having its axis parallel to the axis of plunger 66; and a smaller vent hole 156 is provided at the end of hole 154 extending to the outer end surface 67 of each of plungers 66. Like holes 154a and 156a are drilled in the cylindrical wall of each of the shorter axial plungers 64. In each of mould core assemblies 42 and 44, a cylindrical pin 158 is mounted at one end on annular support ring 80 in any suitable manner, e.g., by the end of pin 158 being threaded and secured in a threaded hole in ring 80 (see mould core assembly 42 at the left of Figure 13). The axis of pin 158 is substantially perpendicular to ring 80 and also is coincident with the axis of holes 154, 156; and the diameter of pin 158 is less than the inside diameter of hole 154. Thus, air may be vented through holes 154, 156 when axial plunger 66 is retracted from the extended position shown in mould core assembly 42 at the left of Figure 13 to the retracted position shown in mould core assembly 44 at the right of Figure 13. The pins 158 have an outer diameter also less than the inner diameter of outer holes 156 at the ends of holes 154 in axial plungers 66 so that the ends of pins 158 will extend into holes 156 and thereby clear from said holes any particles of CM mix 70 which may have entered holes 156 during any of the biaxial CM block casting steps shown in any one or more of Figures 8-11 described above. Similar but shorter pins 158a are similarly mounted on opposite sides of ring 80 in each of mould core assemblies 42 and 44, and pins 158a extend into apertures 154a in the sides of axial plungers 64, with the ends of pins 158a extending into end apertures 156a when the shorter axial plungers 64 are fully retracted. Pins 158a coact with holes 154a, 15a in the shorter axial plungers 64 to vent air when plungers 64 are retracted and also to displace any particles CM mix 70 which may become lodged in the end holes 156a, in like manner as explained above with reference to longer pins 158 and holes 154, 156 of longer axial plungers 66. (It is noted that while only pin 158 in mould core assembly 42 is shown mounted on ring 80, it will be apparent from the foregoing discussion that all pins 158 and 158a in mould core assemblies 42 and 44 are similarly mounted on opposite sides of rings 80 in both mould core assemblies 42 and 44.

Referring now to Figures 9 and 10 plus 13, after the CM mix 70 is compressed and vibrated to form the CM block 30b as shown in Figure 9 and retraction of plungers 64 and 66 is started as shown in Figure 10, there will be resultant substantial negative pressure and vacuum effect between (i) and ends 67 of longer axial plungers 66 and the sides 54 of the mould box 52 and (ii) between the two abutting ends 65 of the shorter axial plungers 64. The holes 154, 156 in the longer axial plungers 66 and the holes 154a, 156a in the shorter axial plungers 64 serve to break such negative pressure and vacuum effect between the ends 67 of plungers 66 and mould walls 54 and between the abutting ends 65 of the plungers 64 when said plungers start to retract as illustrated in Figure 10. Also, when the plungers 64 and 66 are being fully retracted after completion of the step shown in Figure 10 and before start of the step shown in Figure 11, the ends of pins 158 and 158a will respectively extend into holes 156 of plungers 66 and into holes 156a of plungers 64 to dislodge particles of CM mix therefrom and thereby clean the ends of holes 154, 156 and 154a, 156a.

Referring now particularly to mould core 42 at the left of Figure 13 and also to Figure 17, each of biaxial plunger sub-assemblies 45 of each of mould core assemblies 42 and 44 is mounted in its associated mould core 49 by a bracket 160 having a relatively elongated main section 162 and two legs 164 extending substantially perpendicular from sectin 162 as will be apparent from said Figures. The elongated portion 162 of bracket 160 is secured to a bottom portion of assembly sleeve 62 by a pair of screws 166 extending into threaded apertures 168 in the main portion 162 of bracket 160. Each leg 164 of bracket 160 is provided with a threaded aperture 170 which receives a threaded screw member 172 which is provided with a slot 174 (or equivalent means) to enable turning of screw 172 in threaded aperture 170. A nut 176 is screwed onto the threads of screw 172 on the inside of bracket legs 164 as shown in said Figures. After the biaxial plunger sub-assemblies 45 are mounted in apertures 59 in the walls 53 and 53a of mould core assemblies 42 and 44, respectively, bracket 160 is secured to the assembly sleeve 62 by means of screws 166 threaded into holes 168, and then the screws 172 plus nuts 176 are adjusted in relation to bracket legs 164 and side walls 53 and 53a of the mould core 49 so as to finalise the location of each biaxial plunger sub-assembly 45 in relation to side walls 53 and 53a of mould cores 49 and to secure each bracket 160 firmly in relation to its mould core 49. Each respective biaxial plunger sub assemblies 45 is thus secured by like bracket means in like manner to the associated mould core 49 of each mould core assembly 42 and 44. It is noted that the slots indicated at 152 cut in the underside of each of assembly cylinders 62 and the lower opposite sides of each annular ring 80 (as shown in Figures 13 and 17) will extend laterally beyond the sides of the mounting bracket 160 as shown particularly in Figure 17 so as to permit the venting of air from the inside of each cylindrical sleeve 62 to relieve pressure therefrom particularly when the axial plungers

64 and 66 are retracted, as above discussed.

Reference is now made particularly to Figures 13, 16 and 17. Suitable air tubing of metal or the like generally indicated at 178c is connected to the compressed air source by means of a suitable commercially available pressure reduction device 48v whereby air is fed at a low pressure through tubing 178c and via air couplings 124 and 126 to and through tubing 178 to each of mould core assemblies 42 and 44. The flexible tubing 178 suitably connected to and extending from the outlet end of air couplings 124 and 126 is passed through an aperture 180 in the top end surfaces 55 of each of muld cores 49, is "snaked" around the assembly cylinder 62 in each of mould core assemblies 42 and 44, and is connected in series to a pair of nipples 184 which are threaded in apertures in each assembly cylinder 62 so that air will pass through flexible tubing 178 to the inside of cylinders 62 of each mould core assembly 42 and 44. See especially mould core assembly 44 at the right in Figure 13 and both mould core assemblies 42 and 44 shown in Figure 17. Flexible tubing 178 is connected by nipples 184 in like manner to both mould core assemblies 42 and 44 and operation thereof is the same for both assemblies 42 and 44. When the axial plungers 64 and 66 of the mould core assemblies 42 and 44 are retracted during biaxial CM block casting process in the steps illustrated in Figures 10 and 11, it is necessary to assure that all axial plungers 64 and 66 are fully retracted so that all parts thereof are totally disposed inside the walls 53 and 53a of the mould cores 49 as shown at the right of Figure 13 and in Figure 11 *before* the CM block 30b is stripped from the mould 52 by the compression/stripper shoe as shown in Figure 11. The nipples 184 connected to flexible air lines 178 are located so that the aperture in each nipple 184 extending to the inside of assembly sleeve 62 will be blocked off by the "inner ends" of axial plungers 64 and 66 when those plungers are in fully retracted position, as shown particularly in mould core assembly 44 at the right of Figure 13. The nipples 184 in co-operation with their associated air lines 178 serve as "air sensors" for axial plungers 64 and 66 in each of mould core assemblies 42 and 44 to determine whether each and all said plungers 64 and 66 are fully retracted to inside mould core 49 as shown in mould core assembly 44 at the right of Figure 13. That is because if all said axial plungers 64 and 66 are fully retracted there will result a sufficient pre-determined back pressure (e.g., 5 psi or the like) which is measured by a suitable commercially available pressure gauge 48g that is connected to the low pressure line 178c on the input side of air coupling 124 and is mounted on CM casting machine 48 where it can be conveniently observed by the machine operator. Thus, if such back pressure via nipples 184 and air lines 178, 178a is above a predetermined psi level, that indicates that the axial plungers 64 and 66 are fully retracted so that the CM block casting operation can be continued. On the other hand, if all the axial plungers 64 and 66 are not fully retracted, air will pass via air lines 178 through nipples 184 into assembly cylinders 62 and out of vents 152 in the underside thereof; and this will cause a low and insufficient back pressure at the pressure gauge 48g in line 178c on the input side of air coupling 124, thereby indicating that one or more of axial plungers 64 and 66 are not sufficiently retracted. The machine operator can then intervene to put matters aright by manual operation. Further, such "air sensor" arrangement for determining full retraction of plungers 64 and 66 by means of nipples 184 and air lines 178, 178a is also used (i) to discontinue operation of the casting machine 48 if any axial plungers 64 and 66 are not fully retracted or (ii) to permit continued operation of the casting machine 48 if the axial plungers 64 and 66 are fully retracted, as described below.

Referring to Figure 15, the portion of conventional CM casting machine 48 shown in that drawing is made from a press-through of a photograph of a Columbia Machine Model 5 made by Columbia Machine, Inc., located in Vancouver, Washington ("Columbia"). This model Columbia machine makes one block at a time, at the rate of one block about every six seconds. Columbia, however, also makes similar CM casting machines operating in similar manner but which can produce three, six or even 12 CM blocks at a time (a three-block casting machine is believed most commonly used in the U.S.A. CM block making industry). Such Columbia machines, exemplified by Columbia Machine Model 5, have both a manual and automatic cycle operating mode. For the automatic cycle operating mode, the casting machine has a control panel incorporting electro-mechanical control circuitry to operate the machine in a conventional cycle. In a conventional CM block casting process, conventional mould cores similar to cores 49 but having four planar side walls would be used in a conventional manner well known in the art. The control circuitry of casting machine provides a logic pattern for conventional CM casting whereby: (1) the compression/stripper shoe 56 is lifted upwardly above the level of the feed tray 58 and a pallet 60 is raised to form the bottom of mould 52, analogous to the phase of operation shown in Figure 6; (2) the feed tray 58 moves in over the mould 52 below the compression/stripper shoe 56, analogous to the phase of operation shown in Figure 7; (3) CM mix 70 is fed into the cavity of the mould 52 from the feed tray 58, analogous to the phase of operation shown in Figure 8; (4) the feed tray 58 is laterally withdrawn from over the mould 52 permitting the compression/stripper shoe 56 to come down and compress CM mix 70 in the mould 52 as vibration of mould 52 proceeds by conventional means incorporated in CM casting machine 48, analogous to the phase of operation shown in Figure 9; (5) the compressed CM material formed into a conventional CM block such as shown at 30 in Figure 1 is then stripped from the cavity of the mould 52 by simultaneous downward motion of compression/stripper shoe 56 and the bottom pallet 60, analogous to the phase of operation shown in Figure 11; (6) the compression/stripper shoe 56 returns upward past the mould cores while the newly made conventional CM block 30 is being ejected on its individual pallet 60 onto a conveyor; (7) after the compression/

stripper shoe 56 moves upwardly out of and above the mould 52, the above-discussed steps (1) to (6) are then repeated to carry out the next cycle for moulding the next conventional block 30 in like manner as just described above herein. Note that in such a conventional CM block casting process there is no step corresponding or analogous to that shown in Figure 10.

To use the biaxial casting apparatus and process disclosed herein ina conventional Columbia CM casting machine 48, there is provided a suitable commercially available electromechanical control means 48c for the suitable commercially available three-way valve 48v as part of the compressed air control means so as to alternately supply compressed air from a compressed air source to conduit 144 whereby such compressed air passing through tubing 128 to manifold hole 109 will cause axial plungers 64 and 66 in both mould core assemblies 42 and 44 to extend simultaneously. Also, said electromechanical compressed air control means 48c is caused to alternatively operate the three-way valve 48v to alternately supply compressed air to conduit 146 and thus via tubes 132 to hole 108 in manifold 78 so as to simultaneously cause retracting of all plungers 64 and 66 in mould core assemblies 42 and 44. The electromechanical control means 48c for the three-way valve 48v (or other equivalent conventional means) for alternately feeding compressed air from the source to input line 144 (to extend all axial plungers 64 and 66) or to input line 146 (to retract all axial plunges 64 and 66) are appropriately tapped into the electrical control circuitry in the control box 48c of the machine 48 to modify the machine's automatic operations logic pattern so as to change the machine's typical above-discussed conventional moulding cycle to the biaxial CM casting cycle shown in Figures 6-12 and fully described above. Thus the electromechanical means for controlling the three-way valve (or other equivalent means) is tapped into the control circuitry of casting machine 48 to modify its logic whereby: (a) compressed air is fed to line 146 to simultaneously positively retract axial plungers 64 and 66 in both mould core assemblies 42 and 44 as the compression/stripper shoe 56 is raised to above the feed tray 58 and the pallet mould 60 is raised to form the bottom of the mould 52, as shown in Figure 7; (b) compressed air is then supplied by operation of the three-way valve to input conduit 144 to cause the axial plungers 64 and 66 to be simultaneously positively extended and to remain in such extended position, as shown in Figures 7, 8 and 9 for the phases of the biaxial CM casting process shown in said figures and described above; (c) the three-way valve is then switched to supply compressed air to input conduit 146 to cause the axial plungers 64 and 66 to move to simultaneously positively retract after the CM block 30b is formed as shown in Figures 10 and 11, and to maintain said plungers in fully retracted position within the walls of mould cores 49 as shown in Figure 11 *before* the compression/stripper shoe 56 and pallet 60 are permitted or caused to be moved downward to strip the completed CM block 30b from the mould 52 as shown in Figure 11; (d) the compression/stripper shoe 56 is raised up past the mould cores 49 and the fully retracted axial plungers 64 and 66 disposed inside the walls of mould cores 49 while the just-made CM block is moved to a conveyor on its pallet 60 and a new pallet 60 is moved in below the mould 52 to provide a new mould bottom; and (e) the CM biaxial mould process and phases thereof shown in Figures 6-12 is thereafter repeated.

The portion 178a of the low pressure third air line 178; 178a which extends from the input side of the air coupling 124 is connected to a suitable commercially available pressure gauge 48g to indicate to the machine operator whether the back pressure of air at nipples 184 and in lines 178, 178a is (1) equal to or greater than a predetermined minimum back pressure (e.g., 5 psi), thereby indicating to the operator that the axial plungers 64 and 66 are fully retracted, or (2) is below such predetermined minimum back pressure, thereby indicating to the operator that one or more of axial plungers 64 and 66 are not fully retracted. In the latter case (2), the operator can manually stop the machine 48. However, said line 178tc is not only connected to such a pressure gauge but also is connected to a pressure-operated switch which is in turn tapped into the control circuitry to the casting machine 48 to operate as a "go-no go" addition to the machine's control system so that after a CM block 30b has been formed as shown in Figure 9, the machine will not proceed with stripping of the block 30b and removal of the pallet 60 unless all axial plungers 64 and 66 move to fully retracted position as shown in Figure 11 and in assembly 44 at the right of Figure 13. If all axial plungers 64 and 66 are thus fully retracted the thus-modified machine 48 will proceed with the next phase of the block casting cycle involving removala of the CM block 30b as shown in Figure 11, and then automatically proceed with additional CM block making cycles as shown in Figures 6-12 as hereinabove described. However, if all axial plungers 64 and 66 are not fully retracted when they should be (as in Figures 6 and 11) the thus-modified machine 48 will not proceed with the next phase of the biaxial CM casting process: the operator will then determine and fix the problem using manual operation of machine 48.

The operating programme and logic governing the conventional block-making automatic cycle of machine 48 exemplified by Columbia Machine Model 5 is shown in Columbia drawing No. D-328-30-52-1 titled "Control Schematic, Model 5 Block Machine, Stepper Controlled Oscillation". The aforementioned electromechanical controls for operating the three-way valve 48v for alternately supplying air to input conduit 144 to extend all axial plungers 64 and 66 or to input conduit 146 to retract all axial plungers 64 and 66, and the aforementioned pressure-operated switch connected to low pressure input line 178c are suitably tapped into the control arrangement shown in said Columbia drawing to modify the logic and operating programme governing conventional automatic operation of the casting machine so as to perform automatic operation of the biaxial CM casting process of Figures 6-12 as herein disclosed and particularly described with reference to Figures

6-12 plus Figures 13-17.

As will be apparent to one skilled in the art in light of the disclosure and detailed explanation herein of the biaxial CM casting apparatus and biaxial CM casting method of the present inventions, although the same are explained by way of example as used in a Columbia Machine Model 5 casting machine having only one mould, such new biaxial casting apparatus can be installed in like manner in commercially available machines having three moulds, six moulds or even up to twelve moulds by using for such multiple moulds of equal number of mould core systems generally indicated at 41 including mould core assemblies 42 and 44 and core bar and mounting assembly 46 (see Figures 13-14).

It is believed that the construction of the biaxial CM block casting apparatus and its mode of operation and functional results according to the present invention will be clear to one skilled in the art from the disclosure hereinabove, particularly with reference to Figures 13-17 and detailed discussion thereof. It is also believed that the mode of operation of biaxial CM casting process according to the present inventions and functional results according to the present inventions also will be fully apparent from the detailed description hereinabove with reference to Figures 6-12 in conjunction with Figures 13-17.

Reference is now made to Figures 18 and 19 which schematically show modified embodiments of above-described mould core assemblies 42 and 44 that are indicated generally at 42b and 44b. Components of the modified embodiment shown in Figures 18-19 which are the same as corresponding components of the embodiment shown in Figures 13-17 plus Figures 6-12 are identified by like numerals. Components of the modified embodiment of Figures 18-19 which are similar to but changed from components of the embodiment shown in Figures 13-17 plus Figures 6-12 are identified by the same numerals as used in Figures 13-17 and 6-12 plus the letter "b".

Mould core assembly 44b in the embodiment of Figures 18 and 19 is constructed and operated in the same way as mould core assembly 44 shown at the right of Figure 13, excepting that mould core assembly 4b has an axial plunger 64b plus an axial plunger 66. The axial plunger 66 in the modified mould core assembly 44b is the same as axial plunger 66 in mould core assembly 44 shown in Figure 13. The axial plunger 64b of the embodiment in Figures 18-19 is like the axial plunger 64 in mould core assembly 44 shown in Figure 13; but axial plunger 64b of the embodiment as shown in Figures 18-19 is longer than inner axial plunger 64 in the mould core assembly 44 shown in Figures 13-17 and diagrammatically illustrated in Figures 6-12. The inwardly disposed axial plunger 64b of mould core assembly 44b is sufficiently longer than the inwardly disposed axial plunger 64 of core mould assembly 42 in Figure 13 so that when plunger 64b is extended the end 65b thereof will engage the wall 53b of the mould core 49b of mould core assembly 42b. Thus extended plunger 64b will provide a cylindrical end section of plunger 64b which spans the space between wall 53a of mould core assembly 44b and wall 53b of mould core assembly 42b as shown in Figure 19 -- in a manner comparable to the abutting ends 65 of extended plungers 64 of mould core assemblies 42 and 44 as shown in Figures 7-9 (which are analogous to Figure 19). The mould core assembly 42b in the embodiment of Figures 18-19 is similar to the mould core assembly 42 of the embodiment of Figures 13-17 and Figures 6-12 in that mould core assembly 42b has an axial plunger 66 which is the same in construction and mode of operation as the axial plunger 66 of the mould core assembly 42 shown in Figures 13-17 and Figures 6-12. However the modified embodiment of mould core assembly 42b shown in Figures 18-19 differs from the mould core assembly 42 in Figures 13-17 (and illustrated in Figures 6-12) in that mould core assembly 42b in the embodiment of Figures 18-19 has a planar wall 53b (without any apertures such as shown at 59 in wall 53a of mould core assembly 42 at the left of Figure 13). The mould core assembly 42b is built analogously to mould core 42 (and mould core 44) described above in detail with reference to Figures 13-17; but the manifold member in mould core assembly 42b corresponding to manifold 78 of mould core assembly 42 (and 44) is built with only one stationary piston such as shown at 87 at the left in mould core assembly 42 in Figure 13 and with only one axial plunger 66 (like plunger 66 in mould core assembly 42 in Figure 13). The air supply arrangement for the mould core assembly 44b in the embodiment of Figures 18-19 is like that for the mould core assembly 44 described above with reference to Figures 13-17. However, in the embodiment of Figures 18-19 the manifold in mould core assembly 42b corresponding to manifold 78 in mould core assembly 42 (at the left of Figure 13) is modified to provide only air conduits for operation of the single axial plunger 66 in mould core assembly 42b. The air supply means for the mould core assembly 42b are generally similar to those for the mould core assembly 42 at the left of Figure 13. However, such air supply means for mould core assembly 42b are connected to only one set of holes in ring 80 and associated holes in the modified manifold to actuate the single plunger 66 to extend outwardly and retract inwardly (similarly to operation of plunger 66 of the mould core assembly 42 at the left in Figure 13). Further only one nipple 184 is connected to the outer axial sleeve 62 of mould core assembly 42b and connected to a flexible air line 178, with nipple 184 disposed adjacent the end of axial plunger 66 of mould core assembly 42b when said plunger 66 is in fully retracted position so as to operate as an "air sensor" to indicate full retraction of the axial plunger 66 of mould core assembly 42b in a manner like that described above with reference to mould core assembly 42 (and mould core assembly 44) in the embodiment of Figures 13-17 also illustrated in Figures 6-12.

Figure 18 shows the embodiment of Figures 18-19 with the axial plungers 66 and 64b fully retracted similarly to retraction of plungers 64 and 66 in the phase of operation shown in Figure 6 for the embodiment of Figures 13-17 (and also analogous to the phases of operation shown in Figures 11 and 12

for the embodiment of Figures 13-17). The embodiment of Figures 18-19 is shown in Figure 19 with the axial plungers 66 and 64b in extended position similarly to extension of plungers 64 and 66 shown in Figure 7 for the embodiment of Figures 13-17 (and also analogous to extended position of said plungers for the phases of operation shown in Figures 8 and 9 for the embodiment of Figures 13-17).

It is believed that the construction of modified biaxial CM casting apparatus incorporating modified mould core assemblies 42b and 44b of Figures 18-19, and the mode of operation and functional results thereof according to the present invention will be clear to one skilled in the art from the disclosure herein particularly in light of the detailed disclosure of Figures 13-17 and Figures 6-12. It is also believed that the mode of operation of biaxial CM casting process using the modified apparatus embodiment of Figures 18-19 according to the present invention and functioinal results thereof also will be fully apparent to one skilled in the art from the disclosure herein particularly in light of the detailed description with reference to Figures 6-12 of the apparatus embodiment of Figures 13-17.

It is noted that use of the embodiment of Figures13-17 incorporating two like mould core assemblies 42 and 44 particularly shown in Figures 13-15 each having two axial plungers 64 and 66 is preferable to the modified embodiment of Figure 18-19 for purposes of economical volume production of such mould core assemblies due to the greater commonality of parts of the mould core assemblies 42 and 44 of the embodiment of Figure 13-17 as compared to the mould core assemblies 42b and 44b of the embodiment of Figures 18-19. However, the above-described embodiment of Figures 18-19 will perform well also.

Reference is now made particularly to Figures 20-24 which schematically show another modified embodiment of biaxial CM apparatus and method using modifications of above-described mould core assemblies 42 and 44 that are indicated generally at 42c and 44d. Components of the modified embodiment shown in Figures 20-23 which are the same as corresponding components of the embodiment shown in Figures 13-17 or Figures 18-19 (and Figures 6-12) are identified by like numerals and letters. Components of the modified embodiment of Figures 20-24 which are similar to but changed from components of the embodiment shown in Figures 13-17 or Figures 18-19 (and Figures 6-12) are identified by the same numerals as used in Figures 13-17 or Figures 18-19 (and Figures 6-12) plus the letters "c" or "d".

The biaxial CM block casting apparatus shown in Figures 20-23 and the biaxial CM casting process described with reference thereto are used for making a biaxially cast CM "T-block" such as shown in Figure 24 and described with reference thereto. It is noted the CM T-block shown in Figure 24 may also be referred to as a "triaxially cast" CM block, and that the CM casting apparatus and method disclosed in and with reference to Figures 20-23 may also be respectively called a "triaxial CM casting apparatus" and a "triaxial CM casting method."

Mould core assembly 42c in the embodiment of Figures 20-23 is constructed and operated in the same way as mould core assembly 44b shown at the right of Figure 19, as described above (with reference to Figures 13-17), excepting that mould core assembly 42c is inverted left to right compared to mould core assembly 44b shown in Figure 19. The axial plunger 66 in the modified mould core assembly 42c is the same as axial plunger 66 in mould core assembly 42 shown in Figure 13. The axial plunger 64b of mould core assembly 42c is like the axial plunger 64 in mould core assembly 42 shown in Figure 13; but axial plunger 64b of mould core assembly 42c shown in Figures 20-23 is sufficiently longer than inner axial plunger 64 in the mould core assembly 44 shown in Figures 13-17 so that when plunger 64b is extended the end 65b thereof will engage the wall 53d of the mould core 49d of mould core assembly 44d. Thus extended plunger 64b will provide a cylindrical end section of plunger 64b which spans the space between wall 53a of mould core assembly 42c and has its end 65b engaging wall 53c of mould core assembly 44d as shown in Figures 20 and 22, in a manner similar to operation of plunger 64b in mould core assembly 42b as shown in Figure 19 and described with reference thereto.

The embodiment of Figures 20-23 incorporates a mould core assembly 44d which is similar in construction and mode of operation to the mould core assembly 44 of the embodiment of Figures 13-17, but modified mould core assembly 44d of Figures 20-23 differs from mould core assembly 44 of Figures 13-17 as follows (referring to Figures 20-23 compared to Figures 13-17): (1) A modified mould core 49d has a pair of opposed spaced planar side walls 53c (which do not have circular apertures 59 therein as in mould core assembly 44 of Figures 13-15); (2) Modified mould core 49d is provided in opposed planar walls 51d thereof with aligned circular apertures 59d; (3) The mould core sub-assembly (indicated at 45 in Figures 13-15) including assembly cylinder 62 (not shown in Figures 20-24) is mounted and secured in said apertures 59d of mould core 49d in like manner as mould core sub-assembly 45 in the embodiment of Figures 13-15 as above-described; (4) Thus plungers 66d and other related components in their plungers assembly cylinder 62 are disposed (a) perpendicular to like components in mould core assembly 44 in Figures 13-15, and (b) perpendicular to like components of mould core assembly 42c in the embodiment of Figures 20-23; (5) Axial plungers 66d are of equal axial length in mould core assembly 44d in the embodiment of Figures 20-23; and the length of said axial plungers 66d is such that when said plungers are fully extended by compressed air means the ends 67 of plungers 66d will engage the longer mould box side walls indicated at 54' in Figures 25 and 26. (It is noted that longer sides of mould box 52/mould 52 are sometimes indicated by numeral 51' to distinguish said sides from shorter sides 51 of mould box 52/mould 52.1; (6) Dimensions of sleeve 62 and other internal components of mould core assembly 44d will be suitably modified consistent with the foregoing. In the embodiment of Figures 20-24, the compressed air supply and control arrangement for

extending and retracting plungers 66 and 64b of mould core assembly 42c and plungers 66d of mould core assembly 44d, plus the air sensors arrangement for assuring full retraction of said plungers, are the same as described above for the embodimnt of Figures 13-17.

The compressed air supply means and the air-plunger sensor means for the mould core assemblies 42c and 44d, plus the air sensors arrangement for assuring full retraction of said plungers, are the same as described above for the embodiment of Figures 13-17.

The compressed air supply means and the air-plunger sensor means for the mould core assemblies 42c and 44d are similar to those for the respective mould core assemblies 42 and 44 in the embodiment of Figures 13-17 as described above with reference to said Figures. The mould cores 42c and 44d are mounted in like manner as mould core assemblies 42 and 44 of Figures 13-17 on a core bar and mounting means such as indicated at 46, 72, 74, 75 in Figures 13-15. The compressed air means and air sensor means for mould core assemblies 42c and 44d are similarly mounted and connected as for assemblies 42c and 44d are similarly mounted and connected as for asemblies 42 and 44 in Figures 13-17, except that some components like nipples 184 are turned 90 degrees for mould core assembly 44d in the embodiment of Figures 20-24.

The embodiment of Figures 20-24 is shown in Figures 21 and 23 with the four axial plungers 66, 64b and 66d fully retracted similarly to full retraction of plungers 64 and 66 in the phase of operation shown in Figure 6 for the embodiment of Figures 13-17 (and also analogous to the phases of operation shown in Figures 11 and 12 for the embodiment of Figures 13-17). The embodiment of Figures 20-24 is shown in Figures 22 and 24 with the axial plungers 66, 64b and 66d in extended position similarly to extension of plungers 64 and 66 shown in Figure 7 for the embodiment of Figures 13-17 (and also analogous to extended position of said plungers for the phases of operation shown in Figures 8 and 9 for the embodiment of Figures 13-17).

It is believed that the construction of modified biaxial CM casting apparatus incorporating modified mould core assemblies 42c and 44d of Figures 20-24, and the mode of operation and functional results thereof according to the present invention will be clear to one skilled in the art from the disclosure herein particularly in light of the detailed disclosure of Figures 20-24 plus Figures 13-17 and Figures 18-19 with reference to Figures 6-12. It is also believed that the mode of operation of the biaxial CM casting process using the modified apparatus embodiment of Figures 20-24 according to the present invention and functional results thereof also will be fully apparent to one skilled in the art from the disclosure herein particularly in light of the detailed description of Figures 20-25 with reference to Figures 6-12 plus Figures 13-17 and Figures 18-19.

Reference is now made particularly to Figure 24 and 5a (with reference also to Figure 1, and Figures 2-5). Figure 24 shows an embodiment of biaxially cast CM "T-block" made by using the above-described biaxial CM casting apparatus shown in Figures 20-23 and using a biaxial casting method disclosed above with reference to said figures. The T-block made by this modification of biaxial CM casting apparatus and method of Figures 20-23 according to the present invention is generally indicated at 30c in Figure 24 and comprises a pair of longitudinally extending face shells 31c which are interconnected by laterally extending end web 32b, central web 34a, and end web 32c thereby forming two cavities 35c and 35d which extend through CM T-block 30c from the top to the bottom thereof in the direction of the axis of casting as will be apparent from Figure 24 with reference to the other figures mentioned (in the first two sentences of this paragraph). The end web 32b and the central web 34a are each provided with openings 40 which are made by varying the mould cavity during casting and timing such variation of said mould cavity in such a way as to vary the shape of the CM block 30c to provide web openings 40 extending in the direction of a second axis normal to the first axis of casting without a secondary manufacturing operation, as herein disclosed. It is noted that end web 32c is not provided with such an opening 40 (in contrast to biaxially cast CM block 30b shown in Figure 5A and biaxially cast CM block 30a shown in Figures 2-5). The biaxially cast CM T-block 30c is also provided with two substantially aligned openings 40d in opposed portions of the face shells 31c in the region of cavity 35d of block 30c, and said openings 40d in the direction of a third axis normal to the axis of casting and also normal to said second axis of openings 40 in webs 32b and 34a. More particularly, said openings 40 in end web 32b and central web 34a are made by varying the mould cavity during casting and timing such variation by selectively using plungers 66 and 64b of the mould core assembly 42c in extended and retracted positions as shown in Figures 20-23 and above explained. Said openings 40d in the face shells 31c are made by varying the mould cavity during casting and timing such variation of the mould cavity in such a way as to result in variation of the shape of the CM block 30c to provide openings 40d extending normal to the axis of casting and also normal to said second axis of web openings 40 without any secondary or tertiary manufacturing operation as explained here. More particularly, said openings 40d in face shells 31c are made by selectively timed extension and retraction of the axial plungers 66d of mould core assembly 44d of the apparatus disclosed in Figures 20-23 in the operation of said apparatus to perform the biaxial CM casting method described above with reference to Figures 20-23.

Referring again now particularly to Figure 24, the resultant T-block 30c may be joined at its end which has openings 40d in face shells 31c to a pair of biaxially cast CM blocks 30b of configuration such as shown in Figure 5A at the ends of two CM block wall sectioins made up of CM blocks like 30b (or 30a) so that the opening 40 in the end web 32b of the adjoining end block 30b of one such CM block wall sections will be in communication with an opening 40d in one of the two face shells 31c of T-block 30c

and thus also with cavity 35d of such block 30. Similarly, the opening 40 in the end web 32b of the other adjoining end block 30b of the other such CM block wall section will be in communication with the second opening 40d in the other face shell 31c and thus also with cavity 35d of T-block 30c. Hence, piping and/or electrical conduits or the like can be extended through openings 40 in any of such CM blocks 30b into and through one or both face shell openings 40d, cavity 35d and web openings 40 of T-block 30c and then extended in either direction into the perpendicular intersecting walls made up of biaxially cast CM blocks 30b having openings 40 in the end and central webs thereof, as will be apparent to one skilled in the art in light of the showing of CM blocks 30b in conjunction with CM T-block 30c in Figure 24 and explanation thereof herein. It also will be apparent that the biaxially cast CM T-block 30c used in conjunction with the biaxially cast CM blocks 30b as shown in Figure 24 and herein explained to provide a "T-wall-connection" will also enable the flow of air through the cavities within said intersecting CM block walls (called a "T-wall-connection") such as illustrated in Figure 24 and herein described.

Reference is now made particularly to Figures 25-29 which schematically show still another modified embodiments of biaxial CM apparatus and method using modifications of above-described mould core assemblies 42 and 44 in Figures 13-17 and 42b and 43c in Figures 18-19 that are indicated generally at 42c and 44e. Components of the modified embodiments shown in Figures 25-29 which are the same as corresponding components of the embodiment shown in Figures 13-17 or Figures 18-19 (and Figures 6-12) are identified by like numerals and letters. Components of the modified embodiment of Figures 25-29 which are similar to but changed from components of the embodiments shown in Figures 13-17 or Figures 18-19 (and Figures 6-12) are identified by the same numerals and letters as used in Figures 13-17 or Figures 18-19 and 6-12 plus the letter "e".

The biaxial CM block casting apparatus shown in Figures 25-28 and the biaxial CM casting process described with reference thereto are used for making a biaxially cast CM "L-block" or "corner block" such as shown in Figure 29 and described with reference thereto. It is noted that the CM "L-block" shown in Figure 29 may also be called a "triaxially cast" CM block, and that the CM casting apparatus and method disclosed in and with reference to Figures 25-28 may also be called a "triaxial CM casting apparatus" and a "triaxial CM casting method".

Mould core assembly 42c in the embodiment of Figures 25-29 is constructed and operated in the same way as mould core assembly 42c shown at the left of Figure 20, with mould core assembly 42c. See above description of mould core assembly 42c with reference to mould core assemblies 42 and 44 in Figures 13-17 and modified mould core assembly 44b of Figures 18-19 (which is incorporated herein by reference and thus is not repeated here). As in the embodiment in Figures 20-23, when the axial plungers 66 and 64b are extended the end 67 of outer axial plunger 66 will engage the adjacent shorter mould side 54 of muld 52 and the end 65b of inner axial plunger 64b will engage the wall 53c of the mould core 49e of mould core assembly 44e. Thus extended plunger 64b will provide a cylindrical end section of plunger 64b which spans the space between wall 53a of mould core assembly 42c and has its end 65b engaging wall 53c of mould core assembly 44e as shown in Figures 25 and 27 in a manner like operation of plunger 64b in mould core assembly 42c as shown in Figure 20 and described with reference thereto.

The embodiment of Figures 25-28 incorporates a mould core assembly 44e which is similar to the mould core assembly 44d of the embodiment of Figures 20-23 with respect to mounting and orientation of the plunger sub-assembly in mould core 49e; but core 49e of mould core assembly 42e differs from mould core 49d and the biaxial plunger sub-assembly of mould core assembly 44e also differs from mould core assembly 44d which has been fully described above in relation to mould core assembly 44 of Figures 13-17. The modified embodiment of mould core assembly 44e shown in Figures 25-28 further differs from the mould core assembly 44d in Figures 20-24 in like manner as single axial plunger of mould core asesmbly 42b of Figures 18-19 differs in construction and operation from mould core assembly 44 (or 42) of Figures 13-17 as above described with reference to the embodiment of Figures 18-19. In the embodiment of Figures 25-28 (analogous to the embodiment of Figures 18-19) mould core 49 has a planar wall 51 without any aperture such as shown at 59d in wall 51d of mould core assembly 44d at the right of Figures 20 and 21. Like above-described mould core assembly 42b of Figures18-19, mould core assembly 44b is built analogously to mould core 44 (and mould core 42) described above in detail with reference to Figures 13-17; but, as described with reference to mould core assembly 42b in Figures 18-19, the manifold member in mould core assembly 44e corresponding to manifold 78 of mould core assembly 44 in Figures 13-17 is built with only one stationary piston such as shown at 87 in mould core assembly 44 (and 42) in Figure 13 and with only one axial plunger 66d corresponding to plunger 66 in mould core assembly 44 shown in Figures 13-17.

The compressed air suply and air sensor arrangements for the mould core assembly 42c in the embodiment of Figures 25-28 is like that for the mould core assembly described above with reference to Figures 13-17 and with reference to mould core assembly 42c of Figures 20-23. However, as in the above-described mould core assembly 42b in the embodiment of Figures 18-19, the manifold in mould core assembly 44e corresponding to manifold 78 in mould core assembly 44 (at the right of Figure 13) is modified to provide only air conduits for operation of the single axial plunger 66d in mould core assembly 44e. However, the compressed air supply means and the air-plunger sensor means for the mould core assembly 42e are similar to those for the mould core assembly 42c at the left of Figures 18-19

as described above. That is compressed air supply means for mould core assembly 42e are connected to only one set of holes in the modified manifold 78 to actuate the single plunger 66d in relation to a single stationary piston to extend plunger 66d outwardly and retract it inwardly (similarly to operation of plunger 66 at mould core assembly 42b in the embodiment of Figures 18-19 described above). Further, as described with reference to mould core assembly 42b in Figures 18-19, only one nipple such as 184 in Figure 13 in connected to mould core assembly 42e and connected to an air line such as 178 with that nipple disposed adjacent to inner end of axial plunger 66d of mould core assembly 44e is in fully retracted position in a manner like that described above with reference to mould core assembly 42b of Figures 18-19 compared to mould core assembly 42 (and 44) in the embodiment of Figures 13-17.

The embodiment of Figures 25-28 is shown in Figures 25 and 27 with the three axial plungers 66, 64b and 66d fully retracted similarly to retraction of plungers 64 and 66 in the phase of operation shown in Figure 6 for the embodiment of Figures 13-17 (and also analogous to the phases of 13-17). The embodiment of Figures 20-24 is shown in Figures 24 and 26 with the axial plungers 66 and 64b in extended position similarly to extension of plungers 64 and 66 shown in Figure 7 for the embodiment of Figures 13-17 (and also analogous to extended position of said plungers for the phases of operation shown in Figures 8 and 9 for the embodiment of Figures 13-17).

It is believed that the construction of modified biaxial CM casting apparatus incorporating modified mould core assemblies 42c and 44d of Figures 25-28, and the mode of operation and functional results thereof according to the present invention will be clear to one skilled in the art from the disclosure herein particularly in light of the detailed disclosure of Figures 25-28 plus Figures 13-17 and Figures 18-19 with reference to Figures 6-12. It is also believed that the mode of operation of the of the biaxial CM casting process using the modified apparatus embodiment of Figures 25-28 according to the present invention and functional results thereof also will be fully apparent to one skilled in the art from the disclosure herein particularly in the light of the detailed description of Figures 20-25 with reference to Figures 6-12 plus Figures 13-17 and Figures 18-19.

Reference is now made particularly to Figures 29 and 5A (with reference also to Figure 1, and Figures 2-5). Figure 29 shows an embodiment of biaxially cast CM "L-block" made by using the above-described biaxial CM casting apparatus shown in Figures 25-28 and using a biaxial casting method disclosed above with reference to said figures. The L-block made by this modification of biaxial CM casting apparatus and method of Figures 25-28 according to the present invention is generally indicated at 30e in Figure 29 and comprises a pair of longitudinally extending face shells 31c and 31 which are interconnected by laterally extending end web 32b, central web 34a, and end web 32c thereby forming two cavities 35c and 35e which extend through CM L-block 30e from the top to the bottom thereof in the direction of the axis of casting as will be apparent from Figure 29 with reference to the other figures mentioned (in the first two sentences of this paragraph). The end web 32b and the central web 34a are each provided with openings 40 which are made by varying the mould cavity during casting and timing such variation of said mould cavity in such a way as to vary the shape of the CM block 30e to provide web openings 40 extending in the direction of a second axis normal to the first axis of casting without a secondary manufacturing operation, as herein disclosed. It is noted that end web 32c is not provided with such an opening 40 (in contrast to biaxially cast CM block 30b shown in Figure 5A and biaxially cast CM block 30a shown in Figures 2-5). The biaxially cast CM L-block 30e is also provided with one opening 40d in a portion of the face shell 31 in the region of cavity 35e of block 30e, and said opening 40d extends in the direction of a third axis normal to the axis of casting and also normal to said second axis of openings 40 in webs 32b and 34a. More particularly, said openings 40 in end web 32b and central web 34a are made by varying the mould cavity during casting and timing such variation by selectively using plungers 66 and 64b of the mould core assembly 42c in extended and retracted positions as shown in Figures 25-28 and above explained. Said opening 40d in the face shell 31c is made by varying the mould cavity during casting and timing such variation of the mould cavity in such a way as to result in variation of the shape of the CM block 30e to provide openings 40d extending normal to the axis of casting and also normal to said second axis of web openings 40 without any secondary or tertiary manufacturing operation as explained herein. More particularly, said opening 40d in face shell 31c is made by selectively timed extension and retraction of the single axial plunger 66d of mould core assembly 44e of the apparatus disclosed in Figures 25-28 in the operation of said apparatus to perform the biaxial CM casting method described above with reference to Figures 25-28.

Referring again now particularly to Figure 29, the resultant L-block 30e may be joined at its end which has opening 40d in face shell 31c to a biaxially cast CM block 30b of configuration such as shown in Figure 5A at the end of a CM block wall section made up of CM blocks like 30b (or 30a) so that the opening 40 in the end web 32b of the adjoining end block 30b of such a CM block wall section will be in communication with opening 40d in face shell 31c of L-block 30e and thus also with cavity 35e of such block 30e. Hence, piping and/or electrical conduits or the like can be extended through openings 40 in any of such CM blocks 30b into and through face shell opening 40d, cavity 35e and web openings 40 of L-block 30e and then extended at the corner of the two adjoining CM block walls into the perpendicular intersecting wall made up of biaxially cast CM blocks 30b having openings 40 in the end and central webs thereof, as will be apparent to one skilled in the art in light of the showing of CM blocks 30b in conjunction with CM L-block 30e in Figure 29 and explanation thereof herein. It also will be apparent that the biaxially cast

CM T-block 30e used in conjunction with the biaxially cast CM blocks 30b as shown in Figure 29 and herein explained to provide a "corner connection" will also enable the flow of air through the cavities within said intersecting CM block walls (called a "CM block walls corner connection") such as illustrated in Figure 29 and herein described.

Reference is made now to Figures 13-15 for discussion of another modification which is not disclosed as such in the drawings but which will be described with reference to changes made in components shown in said figures. In the embodiment of Figures 13-17, the core bar and mounting assembly generally indicated at 46 and particularly shown in Figures 13-15 includes a conventional type commercially available core bar assembly comprising an elongated core bar 72 with a pair of transversely extending mounting brackets 74 at opposite ends thereof and air couplings 124 and 126 mounted on core bar 72 by welding or any other suitable manner. There are also mounted on core bar 72 air conduit means for connection to a compressed air source and mould core assemblies 42 and 44 for operation thereof to extend and retract the axial plungers 64 and 66. Such air conduit means comprises tubing 144 and 148 plus tubing 128 and related air conduit means connected to and via air blocks 124 and 126 to extend the plungers 64 and 66; and the air conduits for retracting axial plungers 64 and 66 constitutes air tubing 146 and 150 and 132 connected to and via air couplings 124 and 126. Also, the low pressure air conduit for the "air sensor" means to indicate whether or not axial plungers 64 and 6 are fully retracted comprises flexible tubing 178 and air tubing 178a connected to and via air couplings 124 and 126. In lieu of conventional core bar 72, a modified core bar (not shown) may be made incorporating (a) the equivalent of air couplings 124 and 126 and air conduit means 144, 124, 128, 148, 126, 128 for extending plungers 64 and 66, plus (b) the equivalent of air conduit means 146, 124, 132, 150, 126, 132, plus also (c) the equivalent of low air pressure conduit 178a, 124, 178b, 126 and 178. To accomplish this modified core bar assembly embodiment, at least some of said equivalent air conduit means would be formed within a portion of the modified core bar (similar to 72) which will probably be made in two or more parts welded or similarly secured together. This will make such modification of core bar assembly 46 shown in Figure 13-15 more compact and thereby provide advantages for use of a biaxial CM mould core system like that generally indicated at 41 and thus modified as herein discussed. It will be apparent to those skilled in the art in light of the disclosure herein with reference to the embodiment of Figures 13-17 that such modification of core bar 72 to incorporate in the core bar air couplings 124 and 126 and related air conduits extending to, between and from air couplings 124 and 126 may be done in various ways according to such modification of the embodiment of Figures 13-15 as herein discussed.

Reference is now made particularly to Figures 30-31 which disclose a "biaxial maintenance module" generally indicated at 182 which is used for cleaning the axial plungers 64 and 66 of mould core assemblies 42 and 44 of the biaxial CM mould core system 41 shown in Figures 13-17 at the end of a particular run or working day or the like. The maintenance module 182 comprises a base 184 and two side walls 185 and 186 connected at their lower edges to base 184, plus two like end frames 188 connected along their bottom sides to base 184 and along their vertically extending edges to sides 185 and 186. The maintenance module 182 also includes a centre frame 189 connected at the bottom thereof to base 184 and at the sides theeof to side walls 185 and 186. The two like end frames 188 and centre frame 189 may be made in any suitable manner for purposes of mounting below-described cleaning sponges (or equivalent) for cleaning the axial plungers of mould cores 42 and 44; and the particular construction of the biaxial maintenance module 182 shown in Figures 20-22 and below described in detail is exemplary. Each of like end frames 188 and also middle frame 189 is made up of two vertically extending angle-shaped members 190 interconnected by a pair of horizontally extending members 191 to form three substantially square outer frames comprising part of end frames 188 and centre frame 189. Four triangular gussets 192 are secured to members 190 and 191 which form the outer square framework of each of end frames 188 and middle frame 189 as will be apparent from the drawings, particularly Figures 30 and 31. Referring to end frames 188, a cylindrical member 194 of relatively short length is mounted within and secured to gussets 192 of each of end frames 188 in the centre thereof in any suitable manner Similarly, a cylindrical member 195 of relatively short length is mounted within and secured to gussets 192 in the central portion of centre frame 189 in any suitable manner. The bottom 184, sides 185 and 186, end frames 188 and centre frames 189 may be formed of any suitable material, and such components preferably are made of a strong transparent plastic material selected from one of several commercially available plastic materials which are suitable for the construction and usage of biaxial maintenance module 182. Typically, bottom 184 and sides 185 and 186 would be about 1/2 inch thick and members 191 and 192 could be 1/4" X 1" angles. An annular ring 196 or sponge rubber (or suitable equivalent material) is mounted in each of cylinders 194 in end frames 188, as shown particularly in Figure 32. A circular piece of sponge rubber (or suitable equivalent material) indicated at 198 is mounted over the outer face portions of cylindrical sponge rubber rings 196 and secured to cylinders 194 on each of end frames 188, as will be apparent particularly from Figures 32 and 31 of the drawings. Two rings of sponge rubber 196a with a circular piece of sponge rubber 198a disposed there between is mounted in the cylindrical member 195 in the central frame member 189 as shown particularly in Figures 32 and 31 of the drawings. In a typical commercial embodiment of the biaxial maintenance module 182, the sponge rings 196 would be about one inch thick and have an outside diameter of about 5-1/2 inches sized to fit within the inside diameter of rings 194 in which said sponge

rubber rings 196 are secured by any suitable means. Also, the rings 196 would have an inner diameter slightly smaller than the outer diameter of axial plungers 64 and 66 of the mould core assemblies 42 and 44 which are shown particularly in Figure 13 (and likewise with respect to the plungers of modified mould core assemblies 42b and 44b of the modified embodiments of Figures 18-19). The sponge rings 196a would be approximately one-half inch thick (or slightly more) and would have an outer diameter and inner diameter similar to that of rings 196 as above discussed. The circular sponge members 198 disposed on the outer sides of sponge rubber rings 196 of end frames 188 and the circular sponge member 198a disposed between sponge rubber rings 196a in the middle frame 189 are made of sponge rubber (or equivalent material) about 1/8 inch thick in a typical embodiment of biaxial maintenance module 182.

At the end of a run or at the end of a day, or the like, the biaxial maintenance module 182 is used to clean the cylindrical exteriors of axial plungers 64 and 66 and their respective end portions 65 and 67 of biaxial CM mould core system 41 shown in Figures 13-17. Referring now to Figures 6-12, the pallet 60 shown in said Figures is mounted on a vertically moving platen (not shown) which is incorporated in CM casting machine 48 and moves up and down witha pallet 60 to carry out various phases of CM biaxial moulding process shown in Figures 6-12 and above described. To use the biaxial maintenance module 182, the platen is lowered below the mould box 52 of machine 48. The biaxial maintenance module 182 is placed on the thus lowered platen so that when the platen is raised (e.g., as indicated in Figure 6), the mould core assemblies 42 and 44 will respectively enter into the two top open portions of maintenance module 182 with one of said mould core assemblies disposed between centre frame 189 and end frame 188 and the other such assembly disposed between centre frame 189 and the other end frame 188. The biaxial maintainance module 182 is raised within the mould box 52 so that the central axis of each of biaxial plungers 64 and 66 of the mould core assemblies 42 and 44 are coincident with the central axes of axially aligned rings 196 and 196a. The machine 48 is manually operated to cause the plungers 66 of each of the two mould core assemblies 42 to enter the inside of sponge rubber rings 196 with the plunger ends 167 engaging circular end sponges 198 on the frame ends 188. Plungers 64 of each of said mould core assemblies are simultaneously caused to enter into the centres of middle sponge rubber rings 196a with the ends 65 of axial plungers 64 engaging opposite surfaces of the circular sponge 198a mounted on the central frame member 189. The sponges 196, 196a, 198, and 198a are soaked in water and/or in a silicon-containing liquid so as to better clean the surfaces and ends of the axial plungers 64 and 66 by the above-described biaxial maintenance module. Use of the biaxial maintenance module and cleaning of the axial plungers 64 and 66 and ends 65 and 67 thereof as above described is carried out by manual operation of the CM casting machine 48 by the operator.

CLAIMS

1. A biaxial casting apparatus for making a concrete masonry ("CM") blocks including four walls in substantially rectangular plan configuration enclosing a cavity extending through the block in a first direction an an opening extending through at least one of the walls in a second direction transverse to the first direction, the apparatus being adapted to be disposed in the mould of a CM casting machine with said mould including a mould box comprising four substantially vertically disposed side walls disposed in substantially rectangular plan configuration, and the apparatus comprising a mould core having four walls in substantially rectangular plan configuration and enclosing a cavity, the four walls of the mould core being intended to be spaced inwardly from the respective side walls of the mould box to provide the space for casting the four walls of the blocks, a plunger movably mounted in at least one wall of the mould core for movement between a first position extending outwardly from the said wall and a second position retracted into the cavity of the mould core, and means for moving the plunger.

2. A biaxial casting apparatus for making a concrete masonry ("CM") block including a pair of opposing spaced face shells with at least three spaced webs extending transversely to and interconnecting said face shells and forming at least two cavities boundaried by said webs and portions of said face shells, said cavities extending through the CM block in the direction of the axis of casting of such block, said apparatus adapted to be disposed in the mould of a CM casting machine with said mould including a mould box comprising four substantially vertically disposed side ewalls disposed in substantially rectangular plan configuration with a first pair of said side walls being longer than the second pair of said side walls, said biaxial casting apparatus comprising:

(a) at least two mould cores substantially vertically disposed in said mould, said mould cores having substantially vertically disposed side walls arranged in substantially rectangular plan configuration, with a wall of each of said mould cores spaced from a wall of an adjacent mould core, and other walls of said mould cores being spaced from side walls of said mould box so as to form a mould cavity which in plan has a like configuration as the plan of the CM block to be made in said apparatus, with the vertical axis of said mould cores extending in the direction of the axis of casting of a CM block made in said apparatus;

(b) at least one of said mould cores containing means for laterally projecting outwardly from at least one side of said mould core in like longitudinal direction as said first longer mould core in like longitudinal direction as said first longer mould side walls during selected phases of a CM casting process using said apparatus so that said means provides a temporary mould core laterally extending into said mould cavity along an axis transverse to

said axis of casting during such selected phases of using said apparatus in casting a CM block so as to form an opening extending through at least one of the adjacent webs of the resultant CM block with such web opening extending in a direction transverse to the axis of casting;

(c) said mould core also containing means for retracting said outwardly projecting means thereof to within the periphery of said mould core so as to remove said temporary mould core from said mould cavity during other selected phases of such a CM casting process using said apparatus.

3. A biaxial casting apparatus for making a CM block as defined in claim 1 wherein:

(a) said mould core contains means for laterally projecting outwardly from opposite sides of said mould core to provide a pair of temporary mould cores laterally extending into said mould cavity along an axis transverse to the axis of casting during selected phases of using said apparatus for casting a CM block so as to form openings extending through at least two adjacent webs of the resultant CM block with said web openings extending in a direction transverse to the axis of casting.

4. A biaxial casting apparatus for making a CM block as defined in claim 1 wherein:

(a) a second of said mould cores contains means for laterally projecting outwardly from opposite sides of said mould side walls during selected phases of a CM casting process using said apparatus with said means projecting laterally outwardly from opposite sides ofsaid first and second muld cores being substantially aligned and together providing at least three temporary mould cores laterally extending into said mould cavity in like longitudinal direction as said first mould sides and during selected phases of using said apparatus in casting of a CM block so as to form openings extending through each of said three spaced webs of the resultant CM block with each of said web openings extending in a direction transverse to the axis of casting; and

(b) the second of said mould cores also containing means for retracting said outwardly projecting means to within the periphery of said sescond mould core so as to remove the portions of the temporary mould cores formed by said means from said mould cavity during other selected phases of such a CM casting process using said apparatus.

5. A biaxial casting apparatus for making a CM block according to claim 1 wherein:

(a) a second of said mould cores contains means for laterally projecting outwardly from one side of said second mould core in like longitudinal direction of said first longer mould side during selected phases of a CM casting process using said apparatus with said means projecting laterally outward from said first and second mould cores providing at least three temporary mould cores laterally extending into said mould cavity during said selected phases of such CM casting process so as to form openings extending through each of said three webs of the resultant CM block with each of said web openings extending in a direction transverse to the axis of casting;

(b) said second mould core also containing means for retracting this outwardly projecting means thereof to within the periphery of said second mould core so as to remove the temporary mould core portion formed by said means of said mould core from said mould cavity during other selected phases of a CM casting process using said apparatus.

6. A biaxial casting apparatus for making a CM block as defined in claim 2 wherein:

(a) a second of said mould cores contains means for laterally projecting outwardly from at least one of opposite sides of said mould core in like direction as said second shorter mould side walls and transverse to the axis of casting during selected phases of a CM casting process using said apparatus so that said means in said second mould core provides at least one temporary mould core laterally extending into said mould cavity along an axis which is transverse to said axis of casting and also transverse to the direction of the axis of two said web openings during selected phases of using said apparatus for casting a CM block so as to form at least one opening extending through at least one face shell of the CM block between one of said webs which has an opening therein extending in a direction transverse to the axis of casting and another of said webs which does not have any such opening therein;

(b) said second mould core also containing means for retracting said outwardly projecting means to within the periphery of said second mould core so as to remove the temporary mould core formed by said means from said mould cavity during other selected phases of such a CM casting process using said apparatus.

7. A biaxial casting apparatus for making of CM blocks as recited in claim 5 wherein: said second mould core contains means for laterally projecting outwardly from two opposite sides of said mould core in like direction as said second shorter mould side walls to provide a pair of temporary mould core laterally extending into said mould cavity along an axis which is transverse to said axis of casting and also transverse to the direction of the axis of two said openings in said webs during selected phases of using said apparatus in casting a CM block so as to form a pair of substantially aligned openings one each in opposite portions of said faceshells between two webs of the CM block one of which webs has one of said web openings extending therethrough and the other of said webs not having any such opening extending therethrough.

8. A biaxial casting apparatus for making a CM block according to any of claims 1 through 6 further comprising: compressed air means for positively causing said laterally projecting means to extend outwardly of its associated mould core to provide temporary mould cores in the mould cavity and also compressed air means for positively retracting inwardly each of said laterally projecting means to within the periphery of its mould core.

9. A biaxial casting apparatus for making a CM block according to any of claims 1 through 6 wherein said outwardly projecting means for providing said openings in said webs cause the axis of said web openings to extend substantially normal to the axis

said axis of casting during such selected phases of using said apparatus in casting a CM block so as to form an opening extending through at least one of the adjacent webs of the resultant CM block with such web opening extending in a direction transverse to the axis of casting;

(c) said mould core also containing means for retracting said outwardly projecting means thereof to within the periphery of said mould core so as to remove said temporary mould core from said mould cavity during other selected phases of such a CM casting process using said apparatus.

3. A biaxial casting apparatus for making a CM block as defined in claim 1 wherein:

(a) said mould core contains means for laterally projecting outwardly from opposite sides of said mould core to provide a pair of temporary mould cores laterally extending into said mould cavity along an axis transverse to the axis of casting during selected phases of using said apparatus for casting a CM block so as to form openings extending through at least two adjacent webs of the resultant CM block with said web openings extending in a direction transverse to the axis of casting.

4. A biaxial casting apparatus for making a CM block as defined in claim 1 wherein:

(a) a second of said mould cores contains means for laterally projecting outwardly from opposite sides of said mould side walls during selected phases of a CM casting process using said apparatus with said means projecting laterally outwardly from opposite sides ofsaid first and second muld cores being substantially aligned and together providing at least three temporary mould cores laterally extending into said mould cavity in like longitudinal direction as said first mould sides and during selected phases of using said apparatus in casting of a CM block so as to form openings extending through each of said three spaced webs of the resultant CM block with each of said web openings extending in a direction transverse to the axis of casting; and

(b) the second of said mould cores also containing means for retracting said outwardly projecting means to within the periphery of said sescond mould core so as to remove the portions of the temporary mould cores formed by said means from said mould cavity during other selected phases of such a CM casting process using said apparatus.

5. A biaxial casting apparatus for making a CM block according to claim 1 wherein:

(a) a second of said mould cores contains means for laterally projecting outwardly from one side of said second mould core in like longitudinal direction of said first longer mould side during selected phases of a CM casting process using said apparatus with said means projecting laterally outward from said first and second mould cores providing at least three temporary mould cores laterally extending into said mould cavity during said selected phases of such CM casting process so as to form openings extending through each of said three webs of the resultant CM block with each of said web openings extending in a direction transverse to the axis of casting;

(b) said second mould core also containing means for retracting this outwardly projecting means thereof to within the periphery of said second mould core so as to remove the temporary mould core portion formed by said means of said mould core from said mould cavity during other selected phases of a CM casting process using said apparatus.

6. A biaxial casting apparatus for making a CM block as defined in claim 2 wherein:

(a) a second of said mould cores contains means for laterally projecting outwardly from at least one of opposite sides of said mould core in like direction as said second shorter mould side walls and transverse to the axis of casting during selected phases of a CM casting process using said apparatus so that said means in said second mould core provides at least one temporary mould core laterally extending into said mould cavity along an axis which is transverse to said axis of casting and also transverse to the direction of the axis of two said web openings during selected phases of using said apparatus for casting a CM block so as to form at least one opening extending through at least one face shell of the CM block between one of said webs which has an opening therein extending in a direction transverse to the axis of casting and another of said webs which does not have any such opening therein;

(b) said second mould core also containing means for retracting said outwardly projecting means to within the periphery of said second mould core so as to remove the temporary mould core formed by said means from said mould cavity during other selected phases of such a CM casting process using said apparatus.

7. A biaxial casting apparatus for making of CM blocks as recited in claim 5 wherein: said second mould core contains means for laterally projecting outwardly from two opposite sides of said mould core in like direction as said second shorter mould side walls to provide a pair of temporary mould core laterally extending into said mould cavity along an axis which is transverse to said axis of casting and also transverse to the direction of the axis of two said openings in said webs during selected phases of using said apparatus in casting a CM block so as to form a pair of substantially aligned openings one each in opposite portions of said faceshells between two webs of the CM block one of which webs has one of said web openings extending therethrough and the other of said webs not having any such opening extending therethrough.

8. A biaxial casting apparatus for making a CM block according to any of claims 1 through 6 further comprising: compressed air means for positively causing said laterally projecting means to extend outwardly of its associated mould core to provide temporary mould cores in the mould cavity and also compressed air means for positively retracting inwardly each of said laterally projecting means to within the periphery of its mould core.

9. A biaxial casting apparatus for making a CM block according to any of claims 1 through 6 wherein said outwardly projecting means for providing said openings in said webs cause the axis of said web openings to extend substantially normal to the axis

rubber rings 196 are secured by any suitable means. Also, the rings 196 would have an inner diameter slightly smaller than the outer diameter of axial plungers 64 and 66 of the mould core assemblies 42 and 44 which are shown particularly in Figure 13 (and likewise with respect to the plungers of modified mould core assemblies 42b and 44b of the modified embodiments of Figures 18-19). The sponge rings 196a would be approximately one-half inch thick (or slightly more) and would have an outer diameter and inner diameter similar to that of rings 196 as above discussed. The circular sponge members 198 disposed on the outer sides of sponge rubber rings 196 of end frames 188 and the circular sponge member 198a disposed between sponge rubber rings 196a in the middle frame 189 are made of sponge rubber (or equivalent material) about 1/8 inch thick in a typical embodiment of biaxial maintenance module 182.

At the end of a run or at the end of a day, or the like, the biaxial maintenance module 182 is used to clean the cylindrical exteriors of axial plungers 64 and 66 and their respective end portions 65 and 67 of biaxial CM mould core system 41 shown in Figures 13-17. Referring now to Figures 6-12, the pallet 60 shown in said Figures is mounted on a vertically moving platen (not shown) which is incorporated in CM casting machine 48 and moves up and down witha pallet 60 to carry out various phases of CM biaxial moulding process shown in Figures 6-12 and above described. To use the biaxial maintenance module 182, the platen is lowered below the mould box 52 of machine 48. The biaxial maintenance module 182 is placed on the thus lowered platen so that when the platen is raised (e.g., as indicated in Figure 6), the mould core assemblies 42 and 44 will respectively enter into the two top open portions of maintenance module 182 with one of said mould core assemblies disposed between centre frame 189 and end frame 188 and the other such assembly disposed between centre frame 189 and the other end frame 188. The biaxial maintainance module 182 is raised within the mould box 52 so that the central axis of each of biaxial plungers 64 and 66 of the mould core assemblies 42 and 44 are coincident with the central axes of axially aligned rings 196 and 196a. The machine 48 is manually operated to cause the plungers 66 of each of the two mould core assemblies 42 to enter the inside of sponge rubber rings 196 with the plunger ends 167 engaging circular end sponges 198 on the frame ends 188. Plungers 64 of each of said mould core assemblies are simultaneously caused to enter into the centres of middle sponge rubber rings 196a with the ends 65 of axial plungers 64 engaging opposite surfaces of the circular sponge 198a mounted on the central frame member 189. The sponges 196, 196a, 198, and 198a are soaked in water and/or in a silicon-containing liquid so as to better clean the surfaces and ends of the axial plungers 64 and 66 by the above-described biaxial maintenance module. Use of the biaxial maintenance module and cleaning of the axial plungers 64 and 66 and ends 65 and 67 thereof as above described is carried out by manual operation of the CM casting machine 48 by the operator.

CLAIMS

1. A biaxial casting apparatus for making a concrete masonry ("CM") blocks including four walls in substantially rectangular plan configuration enclosing a cavity extending through the block in a first direction an an opening extending through at least one of the walls in a second direction transverse to the first direction, the apparatus being adapted to be disposed in the mould of a CM casting machine with said mould including a mould box comprising four substantially vertically disposed side walls disposed in substantially rectangular plan configuration, and the apparatus comprising a mould core having four walls in substantially rectangular plan configuration and enclosing a cavity, the four walls of the mould core being intended to be spaced inwardly from the respective side walls of the mould box to provide the space for casting the four walls of the blocks, a plunger movably mounted in at least one wall of the mould core for movement between a first position extending outwardly from the said wall and a second position retracted into the cavity of the mould core, and means for moving the plunger.

2. A biaxial casting apparatus for making a concrete masonry ("CM") block including a pair of opposing spaced face shells with at least three spaced webs extending transversely to and interconnecting said face shells and forming at least two cavities boundaried by said webs and portions of said face shells, said cavities extending through the CM block in the direction of the axis of casting of such block, said apparatus adapted to be disposed in the mould of a CM casting machine with said mould including a mould box comprising four substantially vertically disposed side ewalls disposed in substantially rectangular plan configuration with a first pair of said side walls being longer than the second pair of said side walls, said biaxial casting apparatus comprising:

(a) at least two mould cores substantially vertically disposed in said mould, said mould cores having substantially vertically disposed side walls arranged in substantially rectangular plan configuration, with a wall of each of said mould cores spaced from a wall of an adjacent mould core, and other walls of said mould cores being spaced from side walls of said mould box so as to form a mould cavity which in plan has a like configuration as the plan of the CM block to be made in said apparatus, with the vertical axis of said mould cores extending in the direction of the axis of casting of a CM block made in said apparatus;

(b) at least one of said mould cores containing means for laterally projecting outwardly from at least one side of said mould core in like longitudinal direction as said first longer mould core in like longitudinal direction as said first longer mould side walls during selected phases of a CM casting process using said apparatus so that said means provides a temporary mould core laterally extending into said mould cavity along an axis transverse to

of casting.

10. A biaxial casting apparatus for making a CM block according to claim 5 wherein said means for providing a temporary mould core to make said opening in said one face shell forms said opening in said face shell with an axis extending substantially normal to the axis of casting and also substantially normal to the axis of said openings in the webs of the CM block.

11. A biaxial casting apparatus for making a CM block according to claim 6 wherein said means for providing temporary mould cores to make said pair of openings in said face shells forms said openings in said face shells in a direction substantially normal to the axis of casting and also substantially normal to the axis of said openings in the webs of the CM block.

12. A biaxial casting apparatus for making a concrete masonry ("CM") block, substantially as herein before described with reference to Figures 6 to 17 of the accompanying drawings.

13. A biaxial casting apparatus for making a CM block, according to claim 11 but modified substantially as hereinbefore described with reference to Figures 18 and 19 of the accompanying drawings.

14. A biaxial casting apparatus for making a CM block, according to claim 11 but modified substantially as hereinbefore described with reference to Figures 20 to 23 of the accompanying drawings.

15. A biaxial casting apparatus for making a CM block, according to claim 11 but modified substantially as hereinbefore described with reference to Figures 25 to 26 of the accompanying drawings.

16. A biaxial casting apparatus for making a CM block according to claim 11 but modified substantially as hereinbefore described with reference to Figures 27 to 28 of the accompanying drawings.

17. A biaxial casting method using a casting machine and apparatus according to claim 1, comprising the steps of disposing a pallet with respect to the mould box to provide a mould bottom, moving the plunger into its first position, feeding CM mix into the space, vertically lowering compressor/stripper means and compressing the CM mix in the space to form a CM block having an opening in at least one wall occupied by the extended plunger, retracting the plunger into its second position so as to release the plunger from the opening, and moving the compressor/stripper means and the pallet downward to strip the block from the mould box.

18. A biaxial casting method using a casting machine and apparatus for making a concrete masonry ("CM") block having an opening in at least one of the webs thereof as recited in Claim 1, such apparatus also including compressor/stripper means vertically movable with respect to said mould box and mould cores, pallet means vertically and laterally movable with respect to the bottom of said mould box, and CM material feed means laterally movable to above said mould box and away therefrom, said method comprising:

(a) disposing a pallet with respect to said mould box to provide a mould bottom; extending said laterally projecting means from at least one of the mould cores into the mould cavity to provide a temporary mould core laterally extending into the mould cavity along an axis transverse to the axis of casting; feeding CM mix to the mould cavity from said feeder means; and vertically lowering said compressor/stripper means and compressing the CM mix in the mould cavity to form a CM block having an opening extending through at least one of the webs of said CM block in a direction transverse to the axis of casting;

(b) retracting said laterally projecting means to within the periphery of the mould core containing same to remove said temporary mould core from said mould cavity; moving said compressor/stripper means and said pallet downward to strip from said mould box the CM block disposed on said pallet; transferring said CM block and pallet laterally away from below the mould box; placing another pallet below the mould box and vertically raising said pallet to said mould box to provide a mould bottom; and vertically raising said compressor/stripper means from said mould box and disposing it out of the path of said laterally movable CM material feed means.

19. A biaxial casting method using a casting machine and apparatus for making a concrete masonry ("CM") block having an opening in each of the three webs thereof as recited in Claim 3, such apparatus also including compressor/stripper means vertically movable with respect to said mould box and mould cores, pallet means vertically and laterally movable with respect to the bottom of said mould box, and CM material feed means laterally movable to above said mould box and away therefrom, said method comprising:

(a) disposing a pallet with respect to said mould box to provide a mould bottom; extending said laterally projecting means from opposite sides of said mould cores into the mould cavity to provide three temporary mould cores laterally extending into the mould cavity along an axis transverse to the axis of casting; feeding CM mix to the mould cavity from said feeder means; and vertically lowering said compressor/stripper means and compressing the CM mix in the mould cavity to form a CM block having openings extending through each of three webs of said CM block in a direction transverse to the axis of casting;

(b) retracting said laterally projecting means to within the periphery of the mould cores containing same to remove said temporary mould cores from said mould cavity; moving said compressor/stripper means and said pallet downward to strip from said mould box the CM block disposed on said pallet; transferring said CM block and pallet laterally away from below the mould box; placing another pallet below the mould box and vertically raising said pallet to said mould box to provide a mould bottom; and vertically raising said compressor/stripper means from said mould box and disposing it out of the path of said laterally movable CM material feed means.

20. A biaxially casting method using a casting machine and apparatus for making a concrete masonry ("CM") block having an opening in each of the three webs thereof as recited in Claim 4, such

apparatus also including compressor/stripper means vertically movable with respect to said mould box and mould cores, pallet means vertically and laterally movable with respect to the bottom of said mould box, and CM material feed means laterally movable to above said mould box and away therefrom, said method comprising:

(a) disposing a pallet with respect to said mould box to provide a mould bottom; extending said laterally projecting means from sides of said mould cores into the mould cavity to provide three temporary mould cores laterally extending into the mould cavity along an axis transverse to the axis of casting; feeding CM mix to the mould cavity from said feeder means; and vertically lowering said compressor/stripper means and compressing the CM mix in the mould cavity to form a CM block having openings extending through each of three webs of said CM block in a direction transverse to the axis of casting;

(b) retracting said laterally projecting means to within the periphery of the mould cores containing same to remove said temporary mould cores from said mould cavity; moving said compressor/stripper means and said pallet downward to strip from said mould box the CM block disposed on said pallet; transferring said CM block and pallet laterally away from below the mould box; placing another pallet below the mould box and vertically raising said pallet to said mould box to provide a mould bottom; and vertically raising said compressor/stripper means from said mould box and disposing it out of the path of said vertically movable CM material feed means.

21. A biaxial casting method using a casting machine and apparatus for making a concrete masonry ("CM") block having an opening in a least two adjacent webs thereof and in at least one face shell thereof as recited in Claim 5, such apparatus also including compressor/stripper means vertically movable with respet to said mould box and mould cores, pallet means vertically and laterally movable with respect to the bottom of said mould box, and CM material feed means laterally movable to above said mould box and away therefrom, said method comprising:

(a) disposing a pallet with respect to said mould box to provide a mould bottom; extending said laterally projecting means from opposite sides of one of the mould cores into the mould cavity to provide a pair of temporary mould cores laterally extending into the mould cavity along an axis transverse to the axis of casting, and extending laterally projecting means from at least one side of the second mould core in like direction of said second shorter mould side walls to provide at least one temporary mould core extending into the mould cavity in direction of a third axis transverse to both aforementioned axes; feeding CM mix to the mould cavity from said feeder means; and vertically lowering said compressor/stripper means and compressing the CM mix in the mould cavity to form a CM block having openings extending through at least two adjacent webs of said CM block in a direction transverse to the axis of casting and at least one opening extending through at least one face shell of said CM block between a web thereof which has one of said openings therein and another web which does not have such an opening therein;

(b) retracting said laterally projecting means to within the periphery of the mould cores containing same to remove said temporary mould cores from said mould cavity; moving said compressor/stripper means and said pallet downward to strip from said mould box the CM block disposed on said pallet; transferring said CM block and pallet laterally away from below the mould box; placing another pallet below the mould box and vertically raising said pallet to said mould box to provide a mould bottom; and vertically raising said compressor/stripper means from said mould box and disposing it out of the path of said laterally movable CM material feed means.

22. A biaxial casting method using a casting machine aparatus for making a concrete masonry ("CM") block having an opening in a least two adjacent webs thereof and a pair of substantially aligned openings in portions of opposite face shells thereof as recited in Claim 6, such apparatus also including compressor/stripper means vertically movable with respect to said mould box and mould cores, pallet means vertically and laterally movable with respect ot the bottom of said mould box, and CM material feed means laterally movable to above said mould box and away therefrom, said method comprising:

(a) disposing a pallet with respect to said mould box to provide a mould bottom; extending said laterally projecting means from opposite sides of one of the mould cores into the mould cavity to provide a pair of temporary mould cores laterally extending into the mould cavity along an axis transverse to the axis of casting, and extending laterally projecting means from opposite sides of the second mould core in like direction of said second shorter mould side walls to provide a pair of mould cores extending into the mould cavity in direction of a third axis transverse to both aforementioned axes; feeding CM mix to the mould cavity from said feeder means; and vertically lowering said compressor/stripper means and compressing the CM mix in the mould cavity to form a CM block having openings extending through at least two adjacent webs of said CM block in a direction transverse to the axis of casting and a pair of substantially aligned openings one each in opposite portion of said face shells of the CM block between a web thereof which has one of said openings therein and another web which does not have such an opening therein;

(b) retracting said laterally projecting means to within the periphery of the mould cores containing same to remove said temporary mould cores from said mould cavity; moving said compressor/stripper means and said pallet downward to strip from said mould box the CM block disposed on said pallet; transferring said CM block and pallet laterally away from below the mould box; placing another pallet below the mould box and vertically raising said pallet to said mould box to provide a mould bottom; and vertically raising said compressor/stripper means from said mould box and disposing it out of

the path of said laterally movable CM material feed means.

23. A biaxial casting method substantially as hereinbefore described with reference to Figures 6 to 12 of the accompanying drawings.

24. A biaxial casting method substantially as hereinbefore described with reference to Figures 18 and 19 of the accompanying drawings.

25. A biaxial casting method substantially as hereinbefore described with reference to Figures 20 to 23 of the accompanying drawings.

26. A biaxial casting method substantially as hereinbefore described with reference to Figures 25 to 26 of the accompanying drawings.

27. A biaxial casting method substantially as hereinbefore described with reference to Figures 27 to 28 of the accompanying drawings.

28. A biaxially cast concrete masonry ("CM") block made by the method according to claim 17.

29. A biaxially cast concrete masonry block ("CM block") made by a biaxial CM casting method as defined in claim 16 comprising: a pair of opposing spaced face shells; at least three spaced webs extending transversely between and connecting said face shells and forming at least two cavities between pairs of said webs and portions ofsaid face shells, said cavities extending through the CM block in the direction of the axis of casting of such block; at least one of said webs having a biaxially cast opening extending therethrough with the axis of said web openings extending substantially normal to the direction of said axis of casting said block.

30. A biaxially cast concrete masonry block ("CM block") made by a biaxial CM casting method as defined in claim 17 comprising: a pair of opposing spaced face shells; at least three spaced webs extending transversely between and connecting said face shells and forming at least two cavities between pairs of said webs and portions of said face shells, said cavities extending through the CM block in the direction of the axis of casting of such block; at least two of said adjacent webs each having a biaxially cast opening extending therethrough with the axis of said web openings extending substantially normal to the direction of said axis of casting said block.

31. A biaxially cast concrete masonry block ("CM block") made by a biaxial CM casting method as defined in claim 18 comprising: a pair of opposing spaced face shells; at least three spaced webs extending transversely between and connecting said face shells and forming at least two cavities between pairs of said webs and portions of said face shells, said cavities extending through the CM block in the direction of the axis of casting of such block; each of said three webs having a biaxially cast opening extending therethrough with the axis of said web openings extending substantially normal to the direction of said axis of casting said block.

32. A biaxially cast concrete masonry block ("CM block") made by a biaxial CM casting method as defined in claim 20 comprising: a pair of opposing spaced face shells; at least three spaced webs extending transversely between and connecting said face shells and forming at least two cavities between pairs of said webs and portions of said face shells, said cavities extending through the CM block in the direction of the axis of casting of such block; at least two of said adjacent webs each having a biaxially cast opening extending therethrough with the axis of said web openings extending substantially normal to the direction of said axis of casting said block; and at least one opening extending through part of one face shell of said CM block between one of the webs having an opening extending therethrough and another web not having any opening extending therethrough with the axis of casting and also substantially normal to said second axis extending in the direction of said web openings.

33. A biaxially cast concrete masonry block ("CM block") made by a biaxial CM casting method as defined in claim 20 comprising: a pair of opposing spaced face shells; at least three spaced webs extending transversely between and connecting said face shells and forming at least two cavities between pairs of said webs and portions of said face shells, said cavities extending through the CM block in the direction of the axis of casting of such block; at least two of said adjacent webs each having a biaxially cast opening extending therethrough with the axis of said web openings extending substantially normal to the direction of said axis of casting said block; an opening extending through part of one face shell of said CM block between one of the webs having an opening extending therethrough and another web not having any opening extending therethrough, and a second opening in the other face shell of the CM block substantially aligned with said first-recited face shell opening, with the axis of each said face shell opening being substantially normal to the axis of casting and also substantially normal to said second axis extending in the direction of said web openings.

34. A biaxially cast concrete masonry block ("CM block") made by a biaxial CM casting method as disposed in any one of claims 22 to 25.

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